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AUTHOR Fisher, Patience O., Ed.; Leitzel, James R. C., Ed.
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ABSTRACT

This document is primarily intended for postsecondary faculty who are interested in initiating change in the mathematical preparation of teachers. It has been compiled from the experiences of a two-and-one-half day summer workshop held in June 1994, followed by a year in which participating institutions attempted various ways to implement reform in mathematics teacher preparation. Along with discussing a collection of issues in teacher preparation, there are examples from selected institutions of how to deal with those issues. A discussion of the issues and recommendations for the preparation of elementary school teachers, and a discussion of guidelines for the academic preparation of mathematics faculty at two-year colleges is included. The majority of the document is appendices, which contain the following: institutional reports; mathematical preparation of elementary school teachers--issues and recommendations; guidelines for the academic preparation of mathematics faculty at two-year colleges; a workshop schedule; and a workshop participant list. (Author/NB)

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Making the Change

Pioneering Attempts in Implementing Reform in Mathematics Teacher Preparation

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Editors

Patience O. Fisher James R. C. Leitzel

University of Nebraska–Lincoln

ERIC

Members of the Project Writing Team

Glenn Adamson, Ottawa University, Ottawa, KS
James Babb, Minot State University, Minot, ND
Elizabeth D. Behrens, Hastings College, Hastings, NE
Daniel Brahier, Bowling Green State University, Bowling Green, OH
David Cooke, Hastings College, Hastings, NE
Roger Day, Illinois State University, Normal, IL
Patience Fisher, University of Nebraska-Lincoln, Lincoln, NE
Ted Hodgson, Montana State University, Bozeman, MT
Richard G. Holman, Mayville State University, Mayville, ND
James Johnson, Doane College, Crete, NE
James R. C. Leitzel, University of Nebraska-Lincoln, Lincoln, NE
Gary Loontjer, Concordia College, Seward, NE
Cheryl Gregerson Malm, Northwest Missouri State University, Maryville, MO
Elliott Ostler, University of Nebraska-Omaha, Omaha, NE
William Parker, Kansas State University, Manhattan, KS
Joe Raab, Metropolitan State College of Denver, Denver, CO
Bernadette Russek, Plymouth State College, Plymouth, NH
Mel Thornton, University of Nebraska-Lincoln, Lincoln, NE
Mary Jane Wolfe, University of Rio Grande, Rio Grande, OH
Robert W. Wolfe, University of Rio Grande, Rio Grande, OH
Betsy Yanik, Emporia State University, Emporia, KS

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Making the Change —
Pioneering Attempts in Implementing Reform in Mathematics Teacher Preparation

This document is primarily intended for postsecondary faculty who are interested in initiating change in the mathematical preparation of teachers. It has been compiled from the experiences of a two and one-half day summer workshop in June 1994, followed by a year in which participating institutions attempted various ways to implement reform in mathematics teacher preparation. Along with discussing a collection of issues in teacher preparation, there are examples from selected participating institutions of how to deal with those issues. The document's development, much like the efforts to create an enhanced educational experience for prospective and practicing teachers, is very much a work in progress. What is contained here represents what we have been able to achieve thus far. There is still more to be done. This is reflected in the institutional reports contained in Appendix A, where each speaks to the next steps that must be taken.

Overall, those who served on the writing team were in agreement that, in the case of the mathematical preparation of teachers, change is —

needed
possible
hard
slow
on-going
rewarding and refreshing.

Patience O. Fisher
James R. C. Leitzel
University of Nebraska-Lincoln

May 1996

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Making the Change —Pioneering Attempts in Implementing Reform in Mathematics Teacher Preparation

Introduction

Mathematics education in the early part of the 21st century will be different at all levels of the educational spectrum. In the elementary, middle, and high schools, students will be working in groups on problems that have multiple answers, problems that involve the use of technology, real data, and are relevant to their lives now or in the future. Colleges and universities will have received as students the first wave of students educated under paradigms where the NCTM Standards have guided the framing of curriculum and instruction. These freshmen will demand a new format for undergraduate education. These students will demand participation in their own learning. At the graduate level, students will be exposed to an education that provides them with the requisite knowledge and skills to succeed in industry, business, higher education, areas of law, medicine, etc. Getting a PhD to do research in an ivory tower independent of educational responsibility will be a thing of the past. Our challenge is how to prepare ourselves for these impending changes.

Source — *Margaret Cozzens,*
Division Director of Elementary, Secondary and Informal Science Education,
the National Science Foundation

Prospective teachers experience their collegiate courses as an apprenticeship of observation. To reinforce in as strong a way as possible the classroom practices and experiences we want these teachers to demonstrate in their classrooms and with their students, courses in the preservice education program and the content disciplines must support common themes in teaching and learning. Education faculty need to know how content disciplines are using technology in teaching and learning. Faculty teaching content courses need to become comfortable with the use of group learning, more interactive classroom settings, and alternative assessment strategies.

With the changes predicted in mathematics education at all levels for the early part of the 21st century, the importance of cooperation is clear. Implementation in practice is not. Institutional cultures vary—at times, dramatically. Four-year colleges and universities cannot ignore the contributions being made in teacher preparation by our colleagues in two-year colleges. At these institutions, faculty are often quite isolated because there may be only one or two faculty who have responsibility for the content courses in a given mathemat-

ics or science discipline. Cooperation among mathematical sciences and mathematical education faculty must be encouraged. This includes intra-, as well as, inter-institutional efforts.

Concerns and problems have been identified. Recommendations for action are plentiful. What is most needed are time and resources for faculty to engage in effective communication across communities. Mathematics content and education faculty, once they begin talking together, discover that their agendas are very much the same. They have similar concerns and classroom problems. Time for these conversations to take place among faculty is a continuing need because of heavy day-to-day commitments at the home institution. Participants in various faculty workshops indicate that this 'breaking-away' from the usual routine provides opportunity for serious conversation and planning. Resources then need to be available so that faculty can begin to implement the cooperatively developed strategies and other actions to see what is workable in various settings. Innovative approaches for convincing deans and department chairs that providing time for cooperative planning is essential for bringing about creative change in preservice teacher programs.

In situations where content and education faculty have time for interaction, active discussions demonstrate the concern and willingness of these faculty to look for ways to develop enhanced programs for teacher preparation. One side of the camp needs to know what is happening on the other so that student experiences can be mutually reinforcing. In order that the real work gets started, it is critical that we stop 'bashing' one another. Mathematics faculty in many cases are struggling to improve their teaching. They are smart enough to know their students may not be learning. It does not benefit collaborative action to have one group generalize about the other. It is simply not the case that "All mathematics faculty care more for their research than their teaching." And similarly, "All mathematics education research is worthless" is just as improper a stereotype. We should be jointly celebrating our successes rather than pointing out one another's failures. The task of better preparing mathematics teachers for their work in the next century must become a priority matter in our institutions.

Background

To address these issues, a Workshop was held June 2–4, 1994 at the University of Nebraska - Lincoln. The Workshop, *Leading the Way to Systemic Change—The Roles of Mathematics Teacher Educators*, was funded by the National Science Foundation. This document is a report of the discussions on content, pedagogy, and other aspects of teacher preparation programs that took place during the Workshop.

The Workshop was developed on the premise that working together, within and among institutions, mathematics and mathematics education faculty can:

- develop appropriate content courses and other pertinent experiences that will enhance teacher preparation programs;

- create teacher in-service programs that model changes suggested by standards and frameworks;
- establish contact with state-level stakeholders and professional associations.

Mathematics teacher educators —both mathematical sciences and mathematics education faculty—were fully involved in the Workshop program and activities. Institutions were encouraged to send teams that included at least one faculty member with predominant responsibility for teaching courses in mathematics, at least one faculty member with predominant teaching responsibility in mathematics methods/supervision experiences, and either a departmental administrator (chair or associate chair) or a practicing K–12 mathematics teacher. Attendance at the Workshop was 108 individuals, representing 40 different institutions from 20 states. There were four teams representing institutions with enrollment exceeding 20,000 students. Each of these teams included the mathematics department chair as one member of the team. Others represented smaller sized institutions from both the public and private sector. While some participants were from two-year colleges, that component of postsecondary education was not sufficiently represented. [The full list of Workshop participants is given in Appendix E.]

The American Mathematical Association of Two-Year Colleges (AMATYC) has recently released *Crossroads in Mathematics: Standards for Introductory College Mathematics Before Calculus*. This document has a section that speaks to the role of two-year colleges in the preparation of prospective teachers. Reflecting the diverse nature of students attending two-year colleges, and their equally diverse career goals and aspirations, AMATYC has prepared a set of recommendations for those faculty intending to teach at two-year colleges. This set of guidelines is included as Appendix C. Considering that a growing number of prospective elementary teachers receive some, if not all, of their mathematics course work at a two-year college, additional efforts are needed to foster involvement and dialogue with two-year college faculty.

An important outcome of the Workshop was that the participating teams drafted a strategic plan for accomplishing change at their home institutions. During the academic year 1994-95, the teams initiated steps to address the critical aspects of change they identified during the Workshop sessions. The institutional reports on the status of these plans are included as Appendix A.

Some examples of the issues raised during the Workshop discussions:

- What mathematics content is 'essential' for the preparation of a teacher at a given level (elementary, middle, secondary) and how do we present it?
- If we believe effective teaching must be modeled in all classrooms that prepare teachers, how do we encourage and support our colleagues on the road to change?
- Teachers we are currently graduating will be called upon to teach things they have never been taught. How do we provide them with the self-confidence and assurance of being independent learners?

Many participants agreed that, as individual faculty members, they have little impact on state certification practices. However, they also agreed that more attention and public awareness needs to be given to the recommendations of the NCTM *Standards* and those of other professional associations if there is to be any potential for change. As postsecondary institutions change the way they prepare teachers, that change must be reinforced in the students' field experiences. Cooperating teachers should be selected to exemplify the goals the institution is trying to achieve, and those selected to do this important task should be given suitable recognition and reward.

Most participants agreed that there is a critical need to develop better means of communication, to create a vocabulary that will guide future conversations, and for each group to listen carefully and intently not just to the content of the message being sent, but also to the deep feelings contained in the message.

Not long ago, the entry routes to mathematics, the kinds of activity open to a beginner, the kinds of teacher-learner and learner-learner interaction available in the classroom were all shaped by the technology of paper-pencil and a compatible pedagogy that relied heavily on lecturing, practicing, and testing. With the development of innovative computing environments, driven by new visions for teaching and learning mathematics, radically new approaches are emerging. Such approaches advocate teaching methods that are responsive and sensitive to diverse student populations. We need to define what students today should know, should be able to do, and the attitudes they should display as they enter their choice of career.

It is becoming much more important to convey the habits of mind used by mathematicians as they do mathematics. The preparation should be directed toward producing students who are comfortable with ill-posed and fuzzy problems, who see the benefit of systematizing and abstracting, and who look for and develop new ways of describing situations. While it is necessary to infuse courses and curricula with modern content, it is even more important to help students develop the tools they will need to use, understand, and even create mathematics that does not yet exist.

We have experienced an explosive use of technology since 1975. It would not have been possible at that time to design a mathematics curriculum for this present day. Yet, as teacher educators, we are being asked to engage in the development of programs for teacher education that will serve prospective teachers well into the 21st Century. The participants at the *Leading the Way* Workshop were willing to engage in this attempt.

Experiences in Learning

Mathematics learning occurs in a context. Fostering interactive classroom experiences is one method of conveying the vision of mathematics teaching and learning we wish prospective teachers to adopt. These experiences include using technology, using a variety of instructional styles, and providing rich opportunities for prospective and practicing teachers to engage in ongoing

conversation. The institutions participating in this project have thought about each of these themes and are pioneering efforts to include them in their programs for prospective teachers. In this section, we present some of the current plans and program efforts under way.

Technology

Few people today question that prospective teachers must experience the use of technology in their learning of mathematics. Most of the recommendations issued by the professional associations speak directly to the fact that technology changes in dramatic ways our understanding and presentation of mathematical content. Programs preparing teachers of mathematics must assure that students have opportunity to enroll in mathematics courses that make integral use of graphing calculators, computers, and other technology. Courses in the use of technology in teaching offered within teacher preparation programs should complement and reinforce the courses in content areas. Faculty members from these areas should communicate with one another so that students view instruction using technology as natural and based in understanding of how students learn rather than as an "add - on" effort in the classroom. The growing access to and continuing increase of available information on the Internet (e-mail communication, Gophers, World Wide Web sites, etc.) is a resource for teacher preparation that is just beginning to be explored.

There are many examples where using technology in instruction is taking place or getting under way. While at various stages on this road to change, some of the participating institutions share their current thinking, questions, and concerns about implementation.

Emporia State University (Kansas) —
We are making great strides in our effort to incorporate technology into the division's curriculum. For the past two years, we have required that all calculus students purchase a graphing calculator. Last year, the division received an NSF Instrumentation grant that enabled us to create a new mathematics computing laboratory. The computer laboratory has opened this spring term (1995) and is equipped with MAPLE, MATLAB, Geometer's Sketchpad, True BASIC, and additional software that allows us to have a bulletin board for class communication and private journal communication. The laboratory is being used by students in Calculus I, II and III, Differential Equations, College Geometry, Linear Algebra, and the mathematics methods courses. We anticipate that as the faculty and students become more familiar with these software packages their use will extend to almost all courses in our curriculum. We have also designated half of the introductory college algebra sections as graphing calculator sections. Student complaints during the fall, based predominantly on the additional cost for the course, were much reduced in the spring and, overall, students were more receptive to the sections with calculators. The faculty is not unanimous on the matter of requiring calculators in all sections of college algebra. For the time being, we will continue to offer both calculator and non-calculator sections of the course.

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University of Nebraska - Omaha (Nebraska) —
Technology integration into our courses, long a strength at UNO, is now expanding to include active integration of the Internet. This provides students with access to well-accepted mathematics and science based sites, such as the Geometry Forum and the National Center for Supercomputing Adventures. Preservice teachers work with a wide variety of technology-based applications in both methods and content courses. Many of the mathematics courses for secondary majors include the use of the computer algebra system MAPLE. More importantly, the use of technology in teaching has begun a renewed dialogue and interest among a wide variety of stakeholders. We hope to continue and expand these discussions centering on teacher education in mathematics and science.

Plymouth State College (New Hampshire) —
Use of graphing calculators is still being reviewed and discussed. Some people feel it is essential to introduce the graphing calculator into instruction while others argue that traditional algebraic techniques will be sacrificed with the use of such a complex and expensive tool. Expense and management continues to be a concern for our department: If we provide calculators only in the classroom, what do students do for appropriate homework experiences? How much time and energy does learning to use the graphing calculator take away from the learning of mathematics? The faculty is still discussing these issues.

Illinois State University (Illinois) —
The department must expand and upgrade its computer laboratory in order to help provide a richer environment for technology immersion for prospective teachers. Outside funding has been secured through an NSF ILI -IP grant. The upgraded computer laboratory will offer developing mathematics teachers an environment within which they can gain early and substantial experience with technology for teaching and learning mathematics. The networked computer laboratory will be used within several components of the secondary mathematics majors' program to broaden and enrich those students' mathematical explorations.

Varieties of Instructional Style

Quite often, in the discussions among participants, reference was made to the differences in students and their attitudes toward study. It was recognized that understanding the students in current classrooms and how they have changed from ones you may have encountered earlier in your career could be the crucial first step in helping you engage them in the learning and understanding of mathematics. While it may not be commonplace at this time, students soon will be arriving on college campuses having had school experiences representative of the vision in the NCTM *Standards*. These students will expect to be more actively engaged in the learning process. Therefore, at the postsecondary level, faculty should become more comfortable with a variety of instructional styles. These may include cooperative, collaborative, and other forms of group

learning, the development of classroom practice centered more around student learning activities, more use of project work involving student writing and oral presentations, and, in conjunction with those alternatives and the use of technology, a more diverse set of assessment strategies.

Undergraduate instruction at many institutions is beginning to incorporate more of these alternative patterns. Calculus reform has been a strong impetus to change classroom presentations. Key ingredients have been to include more in-depth and open-ended problems and the use of multiple representations of functions — numerical, graphical, and symbolic. These patterns of instruction are well suited to classrooms at all levels and especially in courses designed for prospective teachers of mathematics. To see the variety of efforts being initiated, consider the following excerpts from the reports of institutions participating in this project.

University of Rio Grande (Ohio) —
We had the chance to teach a section of developmental arithmetic for first-year college students using a team-teaching approach. Although much of the instruction was rather traditional lecture/recitation, we introduced new concepts with manipulatives whenever possible. Along with traditional end-of-the-chapter homework problems, students were given writing assignments that focused on problem solving and meta-cognition. Recitations usually comprised group activities. Students used the board when they wished to share a unique or alternative solution with the full class.

Metropolitan State College of Denver (Colorado) —
We are in the process of reforming mathematics instruction for education students to address issues of cooperative, hands-on, problem-centered, integrated approaches to teaching and learning. Through dedicated work of education specialists in the MSCD mathematics department, and of a master teacher from Cherry Creek Schools hired for this purpose, significant reform is taking place. While the instruction is dominated by the styles mentioned above, activities have also focused on how these modes of instruction apply to the future classrooms of the students as teachers.

Bowling Green State University (Ohio) —
In Spring Semester 1995, we taught a course for graduate students holding teaching assistantships but who have had no prior experience teaching. A special component of this course was the attention on the "basics" of assessment in mathematics. The class explored how to write tests, what traditional assessments do and do not tell us about students, and the value of determining more than whether or not students were able to "get the right answer."

Mayville State University (North Dakota) —
We are coordinating plans to provide faculty training sessions for technology use. In particular, emphasis will be placed on the use of Internet resources for teaching and learning.

Early Experiences in the Profession

There appeared to be a consensus among participants concerning the need to provide preservice teachers earlier exposure to current issues in mathematics education. Students come to us with preconceived notions about what it means to teach mathematics based on their personal experiences in the classroom. Most likely these experiences have not taken place in an environment similar to that envisioned by the NCTM *Standards*. In addition to designing mathematics courses in which the instructor models a variety of instructional styles, it is also necessary that we provide students with the opportunity to think deeply about and reflect on teaching and learning. It is also important to provide prospective teachers with the chance to interact with practicing teachers and members of the teacher education faculty early in their study at a postsecondary institution.

Illinois State University (Illinois) —
Members of the secondary mathematics education faculty met during the summer and fall of 1994 to develop a one-credit non-required experimental sophomore/junior-level mathematics education course for secondary majors. The course was approved by the department and the college and was offered for the first time during fall semester 1995 to 20 students. It is intended that the course will be offered every semester.

The aim of the new course is to engage students early in their academic programs in thinking deeply about and reflecting on teaching and learning mathematics. Most students will come to the course with little professional teacher education; their perspectives on the classroom will be from a student's point of view. As a first encounter in mathematics education, it is expected that students' conceptions and beliefs about mathematics learning and teaching will be significantly challenged. An outcome from the experience will be a first draft of a philosophy of teaching, one to be revisited in later mathematics education courses.

To accomplish this aim students will observe video-taped teaching learning episodes as well as live classrooms. In completing the observations, students will focus on the mathematics content in the context of the NCTM *Standards* and the teacher's role in this setting as identified in the NCTM's *Professional Standards for Teaching Mathematics*. In particular, there will be emphasis on selecting worthwhile mathematical tasks, on establishing a learning environment that protects and encourages all students, on examining teacher and student roles in classroom discourse, and on monitoring the teaching and learning in the classroom. Course discussion, reflection, and writing will be conduits for the activities.

Plymouth State College (New Hampshire) —
This year we will be offering an experimental course entitled "Math Activities Center Internship." This course will require students to have a 20 hour internship at the Math Activities Center early in their academic program. This

course is being designed to address a concern of NCATE for an earlier experience component.

Kansas State University (Kansas) —
In the fall of 1994, a new orientation course designed for secondary mathematics education majors was taught. This course met weekly for one hour. Students were required to visit schools, make observations, and interview teachers and counselors. In addition, several sessions were spent discussing issues of gender and equity and the new Kansas requirements for beginning teachers.

In general we felt this course was a good experience for the students who attended. They were, however, juniors and we had intended the experience for freshman or sophomores. To be successful with this course, we believe it needs to be a required course in the secondary mathematics education curriculum, perhaps as a sophomore-level course.

Hastings College (Nebraska) —
We now have available "teaching assistantships" within our own program, allowing second- and third-year students to participate in a lower-level mathematics course. There, under the supervision of the course instructor, they design and teach one or more class sessions. One student who participated in this program in Spring 1995, gained valuable experience not usually afforded to secondary mathematics education majors by taking part in the Geometry Foundations course required for preservice elementary education students.

Redesigning Courses in Mathematics and Mathematics Education

To effectively meet the challenges of change in teacher preparation, there must be a conscious effort to redesign courses in mathematics and mathematics education. While some of the need for rethinking content in existing courses is motivated by change in state requirements for teachers, the vision of classrooms presented by the NCTM *Standards*, the increased availability of technology, and the implications from mathematics education research about how students learn are more important considerations. The widespread adaptation of various calculus reform efforts indicates that mathematics departments are willing to revise instructional practice. Moreover, attention is now being devoted to enhance in similar ways courses that precede and succeed students' experience in calculus. Cooperation and collaboration with faculty in mathematics education becomes more important so that prospective teachers see their content and methods instruction as being complementary and reinforcing, rather than disjoint experiences.

Southwest Missouri State University (Missouri) —
The State of Missouri has revised its teacher certification requirements and initiated a new middle school certification to begin in the fall of 1997. As a result, institutions across the state have been involved in redesigning their teacher education programs to meet these new requirements. Recognizing the need for statewide standards in the mathematics preparation of teachers, state

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professional organizations including the Missouri Mathematics Association for the Advancement of Teacher Training and the Missouri Department of Education have supported and encouraged collaboration among mathematics educators to suggest appropriate curricular experiences and to design new courses.

University of Nebraska - Omaha (Nebraska) —
We are building on the collaborative environment we have established so far. The department of Teacher Education is meeting more routinely with various content area departments. Discussion so far has included the possibility of designing a more integrated approach to content and methods courses, some new content course possibilities, and the potential of creating a new master's degree program. We also hope to work more closely with the Eastern Regional Coalition (of the Nebraska Mathematics and Science Initiative) to involve more community and business related professionals in informal curriculum activities.

Plymouth State College (New Hampshire) —
At Plymouth, the elementary education program is housed in the Department of Education. However, in the past three years, the Department of Mathematics has taken a major role in strengthening that program. They have designed two new mathematics courses making the mathematics component a four-semester sequence. This sequence has just been put into place this spring (1995) and there is still some fine-tuning to be done. However, we are very excited about the strength and scope of the mathematics component now available in the preservice elementary experience.

Institutional Resources and Support

To provide intending K–12 teachers the types of enhanced experiences in learning envisioned by the NCTM *Standards* and described by the project participants, increased attention may need to be directed toward faculty professional development and to departmental reconsideration of the priority it places on teacher preparation. The recasting of courses and curriculum, the more time-intensive instructional styles using writing, projects, group activities, and the introduction of technology, place increased demands on faculty time and energy. In addition, facilities and space requirements for laboratories, the necessary equipment to furnish them, and support staff to keep them functioning, will also stretch limited resources. While some of the additional costs may be supported through external funding, the proposals that secure that funding must be creatively designed and prepared. This activity also absorbs much faculty time. Departmental support, backed by administrative funding commitments, is essential if the changes are to be incorporated fully into the mainstream of the department's offerings.

As an indication of some of the issues that the participating institutions must address, consider the following comments:

> "As a whole, the institution's faculty is unaware of the opportunities presented through access to the internet and have no models for the potential for change that resource provides. Little is being planned institution-wide that will alter that."
>
> "One of the major problems confronting our attempts at change is to have the courses taught by people who have a clear understanding of the objectives of the revised program and who can carry it out."
>
> "Faculty workloads and scheduling may be barriers to implementation of our plans. We might also need to address the attitudes of teaching assistants toward issues in mathematics education and their possible lack of willingness to cooperate in the planned instructional changes."
>
> "Mathematicians and scientists are often skeptical of the reform movement. In order to develop a truly reformed program, content specialists must embrace and actively participate in course development."
>
> "Ideally, pre-service mathematics and science courses should prepare students as content specialists and provide models of appropriate pedagogy. To accomplish this, the traditional separation of methods and content needs to be eliminated. Methods of teaching mathematics and science courses should be integrated into existing content courses. Unfortunately, faculty schedules, the physical separation of faculty along college lines, and the reluctance of departments to alter existing programs do not facilitate cooperative work. Concerted effort is needed to ensure the cooperation of all faculty in this effort to integrate content and methods."

Frequently, those participating in the Workshop spoke of this need for expanded communication and collaboration. One of the participants noted that we were really dealing with some fundamental change. The reality of competition for scarce resources may inhibit consistent and complementary curricular development. Increased communication is essential to bridge isolated approaches and foster cooperation. Finally, we will be at the stage where true collaboration is in place. Change is hard and it takes time.

It was clear to those planning revisions that, with the accelerating pace of change taking place in mathematics education, it is critically important that faculty have increased opportunity for professional development. Departments should encourage and support faculty who wish to take professional development leaves to visit other institutions where active efforts are under way to revise teacher preparation programs. Chairs of departments play a key role in this endeavor. Active encouragement from the administration will enable faculty to act on the opportunities currently available. It is not possible to list here the variety of available programs. All faculty should be actively involved

in some program of growth in their effectiveness as teachers and scholars. All faculty should be members of one of the mathematical professional associations. These associations offer many such programs at state, regional, and national meetings. The National Science Foundation funded workshops and teacher enhancement programs provide a rich source of information and instructional development.

In their institutional setting, faculty assume many roles. Among these are the key and critical roles of instruction and instructional development. As courses and programs incorporate more use of technology and varied instructional styles — increased emphasis on writing, use of projects, group interactive learning — innovative approaches in using these alternatives and sharing the lessons learned with others should be included in the reward and recognition structure adopted by departments. Models of how this can be effectively done are beginning to emerge. Departments that have the enhancement of the undergraduate experience for all students as a priority will need to address this issue quickly and positively.

Issues Needing Further Attention

The challenge for teachers will not be content, but incorporating appropriate pedagogy and assessment into classroom activities.

Source — *Pamela Matthews, Mt. Hood Community College, Gresham, OR*

Assessment

As pioneering attempts at changing teacher preparation begin, it is clear that the pre-service teacher must increasingly become aware that mathematical techniques need to be distinguished from mathematical concepts. They have to move away from a mind-set of algorithmic learning to a more constructive approach in building understanding. One major issue along this road to change is how to alter assessment practices in courses to reflect these new learning goals. Many current faculty have had little or no experience with alternative methods of assessment. In many instances, faculty in content areas have not seriously considered issues centering around what traditional assessment practices really tell us about what students do and do not know. Equally important is coming to realize the inherent value in determining more than whether the student has achieved the "right answer" to a problem or task.

As the vision of the NCTM *Standards* becomes more common in schools at the K–12 level, postsecondary faculty will need to take the lead in rethinking admissions policies for their institutions. Standardized tests such as the ACT and SAT are beginning to move to incorporate technology and other alternative assessment strategies. Several schools are developing and adopting senior level options that provide students with experiences different from the more traditional calculus course.

Multicultural Issues/Equity

Minorities and women continue to be seriously underrepresented in higher level mathematics courses and, as a result, in careers that require a working knowledge of mathematics. Too frequently, these students end their study of mathematics when they have satisfied the minimum requirement for high school graduation or for admission to postsecondary education. For various reasons, many more drop out early in their college programs and consequently shift career goals to those that do not require a mathematical background. This trend has an economic impact for our society. In today's technological era we simply cannot continue to have the majority of our workers inadequately prepared in mathematics.

The Board of Directors of the National Council of Teachers of Mathematics has set as a goal the mathematical education of every child at all levels, K–12. By "every child" they mean specifically:

- students who have been denied access in any way to educational opportunities as well as those who have not;
- students who are African American, Latino/Latina, Native American, and other minorities as well as those who are considered to be part of the majority;
- students who are female as well as those who are male; and
- students who have not been successful as well as those who have been successful in school and in mathematics.

Programs preparing our future teachers must pay attention to this goal. Issues of equity and diversity must be addressed in all courses so that students become more aware of the problem. However, programs must go beyond building awareness. They need to provide a framework for prospective teachers to ensure that all of their students are both adequately prepared in mathematics and have developed respect for the diverse contributions made by people of other cultures. Related to this is the goal that all students develop a positive disposition toward mathematics and understand the importance of mathematics in our society.

As stated in MAA's *A Call for Change* (page 8): Mathematics is a truly human endeavor. Its teaching should include a close look at the development of mathematical ideas and the women and men who have contributed to that development throughout history and who are playing important roles in mathematics today. These mathematical ideas should not be rooted solely in the past. We who are teaching collegiate mathematics should make our students aware of the striking new developments taking place today in mathematics and its applications. An understanding of mathematicians as people, with their wonderful diversity of personalities, idiosyncrasies, backgrounds and interests is vital for those who will be teaching mathematics. We need to share our appreciation of the contributions of mathematics to society and the impact of mathematicians on society.

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While progress toward reaching these goals is being made, there is still much work to be done. The following examples illustrate just some of the efforts that are being undertaken.

Montana State University (Montana) —
The number of women and other minorities teaching mathematics and science in Montana has increased significantly in recent years. Yet, the number of men teaching these subjects is still much greater than the number of women and minorities. In particular, there is a critical shortage of Native American teachers. Although 10% of Montana's school population is Native American, there are but a handful of Native American teachers. Thus, the recruitment and support of talented women and minorities is a primary goal of the Systemic Teacher Excellence Preparation Project (STEP). In order to increase the number of minorities (which in Montana is mostly Native American), STEP has developed strong ties with seven tribal colleges in Montana. In these schools, which are located on Indian reservations, numerous programs are being put into place to increase the number of K–12 Native American teachers.

Although Montana is the fourth largest state in the Union, its population is one of the smallest. As a result, Montana's schools are generally small, its teachers are forced to teach multiple subject areas, and the distances separating schools effectively isolates teachers. Although issues regarding rural education are addressed in various ways by the Montana University System, better models need to be developed regarding the preparation of preservice teachers entering rural schools.

Two steps were initiated during the 1994–95 academic year to prepare preservice teachers for rural settings and support these teachers once they accept rural teaching positions. First, an Early Career Committee composed of representatives from Montana State University, the STEP Project, the Montana Council of Teachers of Mathematics, and the Montana Science Teachers Association was established. The committee will begin a mentoring program for entering teachers, based an a similar program established in Connecticut. They will conduct a series of workshops during the summer of 1996. Additionally, the committee will design early career survival kits and distribute these to teachers entering rural school assignments in Fall 1996. The establishment of a state-of-the-art telecommunications network will also provide professional support for beginning teachers in rural settings.

Emporia State University (Kansas) —
Success in reaching underrepresented populations has been limited. Each October we host a Mathematics Day for high school students from surrounding districts. Approximately 400 students, most of whom come from rural school districts, participate in team and individual mathematics contests in algebra, geometry, and precalculus. This year the Divisions of Mathematics and Computer Science, Biology, and Physical Sciences worked together to sponsor a conference, *Expanding Your Horizons*. This conference, for middle school girls, was designed to increase their interest in mathematics and science and

in their awareness of career opportunities in these areas. A parallel program was provided for teachers and parents. Approximately 200 girls and 50 adults attended last year's conference. With the support of the dean of the College of Liberal Arts and Sciences and the University administration, plans are being made to host a similar event next year. For high school women, we hosted a "Sonia Kovalevsky Day" supported by a grant from the Association for Women in Mathematics. Approximately 70 women participated in mathematics workshops, a mathematics scholarship competition, and discussions with successful career women in the mathematical sciences.

The Division of Mathematics and Computer Science and the University have been active in trying to recruit faculty from underrepresented populations. One disadvantage we have in that regard is that we are located in a small midwestern city. However, our division has been very successful in recruiting women faculty. We have three women, all holding the Ph.D. and two at the rank of Associate Professor, on our faculty of twelve.

Our region has a large Hispanic population and there is a need to provide mathematical opportunities for this group. We hope to be able to secure additional funding to continue and expand our efforts in this area.

Kansas State University (Kansas) —
In the newly designed courses for teacher preparation, several weeks are spent discussing issues related to gender and equity.

University of Nebraska - Omaha (Nebraska) —
Over the past year, we have seen an increased participation in our minority internship program related to mathematics and science education. We have also made special efforts to infuse multi-cultural issues and concepts into the methods course sequence.

Conclusions and Recommendations

The duty of presidents, chancellors, and deans to promote the well-being of their institutions is clear, but in recent decades, many faculty, especially scientists, have given their primary loyalty to disciplines and to national and international professional groups. This tendency is not new, but it has been magnified by the focus on outside resources and on an international reputation as a criterion for tenure.

Source — *William H. Danforth, Chairman of the Board of Washington University, St. Louis, MO, in an editorial in* Science, *Vol 269, September 22, 1995*

To enable schools at the K–12 level to achieve the NCTM Standards' vision of mathematics teaching and learning, postsecondary institutions play a major role in preparing mathematics teachers who are confident and capable of accomplishing that task. Documents prepared by the professional mathemati-

cal associations give guidance, direction, and support to initiate change. But to implement that change requires commitment on the part of postsecondary faculty. And in that commitment, collaboration among faculty groups is critical. There must be continuing dialogue among mathematics, mathematics education, and teacher education faculty and with practicing K–12 teachers. Without resources and other forms of support committed by departments and administrative offices in the postsecondary institution, that change will falter. To facilitate that dialogue, Ceri Dean and Jeff Johnson of the Eisenhower High Plains Consortium of Mathematics and Science (HPC), have organized an electronic mailing list (MATE—Mathematicians And Teacher Education) devoted to continued discussion of issues related to the teaching of undergraduate mathematics and the preparation of K–16 mathematics educators. The list is maintained by HPC of the Mid-continent Regional Educational Laboratory (McREL). To subscribe to that list, send a message to majordomo@mcrel.org, with no subject line, and in the body of the message "subscribe mate".

The preparation of teachers of mathematics for the elementary grades is critically important and deserves continued attention by postsecondary institutions. Guidance from the professional associations can support these efforts. At the request of five major professional associations (The American Mathematical Association of Two-Year Colleges (AMATYC), The American Mathematical Society (AMS), The Mathematical Association of America (MAA), The National Council of Teachers of Mathematics (NCTM), and the Society for Industrial and Applied Mathematics (SIAM)), the Mathematical Sciences Education Board prepared a series of issues and recommendations for consideration. Three specific charges were noted:

- The mathematics professional societies should develop and make public a consensus statement regarding the critical importance of the mathematical preparation of elementary school teachers.
- The mathematics professional societies should develop a coordinated program of activities and publications to support their members in providing outstanding mathematical education to prospective elementary school teachers.
- The mathematics professional societies should work both at the national level and with their state and local affiliates to develop strategies for engaging and influencing educational policy.

Each of these statements was elaborated by citing recommendations already made by the participating organizations or by suggesting strategies that could be undertaken. The complete report is included as Appendix B.

The participants in this project, like many others in the postsecondary community, fully agree that change in teacher preparation is needed. They have, in the efforts already undertaken at their home institutions, shown that change is possible. However, even the change that has been started requires much in terms of time and resources. It took a great deal of effort on the part of individual faculty working to convince others that the changes would be benefi-

cial. These discussions were (and in some cases, still are) painful and slow. One cannot embark on the effort to change programs and expect overnight results. But, each one speaks of how developing and implementing these changes has been exciting, effective, and personally rewarding. They have provided unusual opportunities for the faculty to be creative in their work and the results with students have been extremely refreshing.

A recommendation to all postsecondary faculty, succinctly put, is —

1. **Become more professionally involved.**

   Some suggestions for getting started in this involvement include:
   - Join appropriate professional organizations: The Mathematical Association of America (MAA), The American Mathematical Association of Two-Year Colleges (AMATYC), the Association of Mathematics Teacher Educators (AMTE), The National Council of Teachers of Mathematics (NCTM), The National Council of Supervisors of Mathematics (NCSM), and state/local affiliates of these groups.
   - Become active at professional meetings: give presentations, serve on planning committees.
   - Acquire a broad picture of reform efforts — postsecondary faculty need to be aware of changes at the K–12 level, particularly in their local areas.
   - Start some activities at your home institution: seminars on topics in undergraduate mathematics education, brown-bag lunch discussions, joint lesson planning with other colleagues, preparation of ideas to enhance student-faculty interactions (e.g., start a local mathematics club).
   - Begin interactions on use of technology in the teaching and learning of mathematics for all students as well as those intending to become teachers of mathematics.
   - Initiate dialogue with colleagues about how we teach students and assess their learning, bridging the conversation to include K–12 teachers and students.

A second recommendation, directed to departmental chairs, deans, and others in the administration is —

2. **Modify the institutional reward and recognition structure.**

   Some suggestions that merit consideration include:
   - Institute and permit faculty professional development leaves (or sabbaticals) for curricular reform activities.
   - In salary reviews and promotion cases, establish a process that takes into serious consideration the broad range of educational activities of the faculty member including such items as significant involvement with K–12 issues, working with colleagues in other areas on important problems in teaching and learning, being an advocate for enhancement of the curricular experiences for students by addressing changes in pedagogy, use of technology, and alternative assessment strategies.

- Recognize that research in undergraduate mathematics education is an important and expanding scholarly activity.
- Encourage faculty participation in professional development activities such as workshops and minicourses at professional meetings, short courses and conferences sponsored by professional associations and funded projects, and reviewing proposals for funding agencies.

A third recommendation speaks to the mathematical professional associations and funding agencies. In brief,

3. **Continue and expand faculty professional development opportunities.**

Funding agencies and professional associations currently provide several avenues for faculty professional development. The participants in this project applaud the efforts currently in place, but urge these groups to expand the opportunities so that:

- There are an increased number of presentations relating to issues of higher education in general, and teacher preparation in particular, at state, regional, and national meetings of the professional associations.
- There is increased attention and funding for workshops and conferences similar to those currently funded through the Faculty Enhancement Program of the National Science Foundation. Similarly, to stimulate faculty involvement in curricular change, additional funding sources should be available that complement the Undergraduate Course and Curriculum program at the National Science Foundation.
- There is increased opportunity for faculty to visit institutions where changes have been successfully implemented.

The postsecondary institutions that were involved in this *Leading the Way* Workshop have begun to make changes. In a sense, these efforts are pioneering since the tasks match those of early settlers—breaking new trails, fertilizing the ground, and planting the seeds of change. However, we cannot sit back and expect growth of the ideas to occur without continued attention. The examples presented in this document show that change is possible, although it is hard and occurs slowly. Change must be on-going, for it is easy to slip back to previous patterns. But undertaking change is rewarding to both faculty and students.

Because the project included representatives from a diverse set of postsecondary institutions, we hope that others can "find themselves" matched in terms of institutional size, mission, and commitment. We encourage that identification and challenge you to join as a pioneer in beginning change in teacher preparation at your institution. Our preservice teachers and their future students depend on us to prepare them well for the challenges they will face in the next century.

Resources

1. *A Call for Change: Recommendation for the Mathematical Preparation of Teachers of Mathematics,* 1991, MAA Report of the Committee on the Mathematical Education of Teachers, The Mathematical Association of America, Washington, DC.
2. *Assessing Calculus Reform Efforts,* 1995, The Mathematical Association of America, Washington, DC.
3. *Assessment Standards for School Mathematics,* 1995, National Council of Teachers of Mathematics, Reston, VA.
4. *A Source Book for College Mathematics Teaching,* 1990, MAA Committee on the Teaching of Undergraduate Mathematics, The Mathematical Association of America, Washington, DC.
5. *Calculus for a New Century,* MAA Notes Number 6, 1988, The Mathematical Association of America, Washington, DC.
6. *Challenges for College Mathematics: An Agenda for the Next Decade,* Report of a Joint Task Force of the Mathematical Association of America and the Association of American Colleges, MAA FOCUS, November-December, 1990.
7. *Counting On You: Actions Supporting Mathematics Teaching Standards,* 1991, National Academy Press, Washington, DC.
8. *Crossroads in Mathematics: Standards for Introductory College Mathematics Before Calculus,* 1995, American Mathematical Association of Two-Year Colleges, Memphis, TN.
9. *Curriculum and Evaluation Standards for School Mathematics,* 1989, National Council of Teachers of Mathematics, Reston, VA.
10. *Everybody Counts: A Report to the Nation on the Future of Mathematics Education,* 1989, National Academy Press, Washington, DC.
11. *Guidelines for Mathematics Departments at Two-Year Colleges,* 1993, American Mathematical Association of Two-Year Colleges, Memphis, TN.
12. *Guidelines for Programs and Departments in Undergraduate Mathematical Sciences,* 1993, The Mathematical Association of America, Washington, DC.
13. *Heeding the Call for Change: Suggestions for Curricular Action,* MAA Notes Number 22, 1992, The Mathematical Association of America, Washington, DC.
14. *Mathematics Education: Wellspring of U.S. Industrial Strength,* 1988, National Academy Press, Washington, DC.
15. *Measuring What Counts: A Conceptual Guide for Mathematics Assessment,* 1994, National Academy Press, Washington, DC.
16. *Moving Beyond Myths: Revitalizing Undergraduate Mathematics,* 1991, National Academy Press, Washington, DC.
17. *On the Shoulders of Giants: New Approaches to Numeracy,* 1990, National Academy Press, Washington, DC.
18. *Priming the Calculus Pump: Innovations and Resources,* MAA Notes Number 17, 1990, The Mathematical Association of America, Washington, DC.
19. *Professional Standards for Teaching Mathematics,* 1991, National Council of Teachers of Mathematics, Reston, VA.
20. *Renewing U.S. Mathematics: A Plan for the 1990's,* 1990, National Academy Press, Washington, DC.
21. *Reshaping College Mathematics,* MAA Notes Number 13, 1989, The Mathematical Association of America, Washington, DC.
22. *Reshaping School Mathematics: A Philosophy and Framework for Curriculum,* 1990, National Academy Press, Washington, DC.
23. *Toward a Lean and Lively Calculus,* MAA Notes Number 6, 1986, The Mathematical Association of America, Washington, DC.

Appendix A
Institutional Reports

This section contains reports from institutions that participated in the *Leading the Way Project*. The organization of the reports is alphabetical by institution. The table immediately following the list of reporting institutions gives the required and elective courses currently required for teacher certification at the secondary level. Information regarding elementary and middle level certification is contained on the Demographic Information page for the institution. Each institution has also provided a short report addressing their attempts at pioneering change during the 1994-95 academic year and a statement of the next steps to be undertaken.

List of Reporting Institutions

Table of Required and Elective Courses for Certification

School Courses	Calculus 1	Calculus 2	Calculus 3	Linear Algebra	Differential Equations	Foundations Logic	Geometry	Probability Statistics	Discrete Mathematics
Emporia State U.	X	X	X	X			X	X	X
Illinois State U.	X	X	X	X	X*		X	X	X
Kansas State U.	X	X	X		X		*	X	
Mayville State U.	X	X	X	*	*	*	*	*	
Minot State U.	X	X	X	X			X	X	X
Montana State U.	X	X	X	X	*	X	X	X	
U. of Wisconsin-Oshkosh	X	X	X	*		X	X	X	X
U. of Missouri-Columbia	X	X	X	*	X		X	X	X
U. of Nebraska-Lincoln	X	X	X	X	*	X	X	X	*
Southwest Missouri State	X	X	X	X			X	X	
Hastings College	X	X	X	X	*	X	X	X	*
Bowling Green	X	X	X	X		*	X	X	X
U. of Rio Grande	X	X	X	*	*		X	X	

School Courses	Number Theory	Real Analysis	Complex Analysis	Topology	Abstract Algebra	Numerical Analysis	History of Mathematics	Computer Science	
Emporia State U.					X		X	X	
Illinois State U.	X*	X*			X			X	
Kansas State U.		*			*		*	X	
Mayville State U.	*	*			*		*		
Minot State U.	X						X	X	
Montana State U.							X	X	
U. of Wisconsin-Oshkosh	*				*				
U. of Missouri-Columbia	*			*	*	*		X	
U. of Nebraska-Lincoln	*	*		*	X	*		X	
Southwest Missouri State	*				*		X	X	
Hastings College		X	*		X	*		X	
Bowling Green		*			X				
U. of Rio Grande	*	*	*	*	*		X		

*indicates that course is on a list of required electives.

Bowling Green State University
Bowling Green, Ohio

Contact person: Daniel J. Brahier
EDCI - 529 Education Building
Bowling Green, OH 43403
Phone: (419) 372-0339
e-mail: brahier@bgnet.bgsu.edu

Demographics Information

Type of school: 4 year

Size of undergraduate student population: 17,000

Average number of graduates over the past three years:
Secondary mathematics: 45
Elementary (general): 250
Elementary (math specialist): 40
Middle Level/Junior High: N/A

Course Information

A. Elementary Program
Required number of hours in mathematics: 6
Additional number of hours required for elementary specialty in mathematics: 22
Required number of hours in mathematics methods: 3 (6 if speciality in mathematics)

B. Middle Level/Junior High Program
Required number of hours in mathematics: N/A (Program currently being developed.)
Required number of hours in mathematics methods: N/A

C. Secondary Program
Required number of hours in mathematics: 35
Required number of hours in mathematics methods: 3

Mathematics courses in addition to those shown in table.

Required	Electives
	One additional course

Institutional Mission

Bowling Green State University is dedicated to providing quality academic programs in a learning environment that promotes academic and personal excellence in students, as well as appreciation of intellectual, ethical, and aesthetic values. Wisdom, sound judgment, tolerance and respect for other persons, cultures and ideas are hallmarks of an educated person and the characteristics that the university hopes to develop in students. The University strives to attract the most qualified students and faculty committed to goals of productive research, quality education and scholarly achievement.

Institutional Approach

The following three goals were established and addressed at Bowling Green State University for the 1994-95 academic year: (1) to improve existing lines of communication between the mathematics and mathematics education units, (2) to broaden the understanding of alternative forms of assessment, and (3) to develop interdepartmental teaching schedules. A strategic plan was developed to address the stated goals. The plan included the following actions to be taken:

(1) To invite a prominent mathematics educator to speak to the issues of research in mathematics education to both mathematics department and education faculty.

In the Fall of 1994, Dr. Frank Lester, chief editor of the Journal for Research in Mathematics Education, was invited to present a colloquium for the Department of Mathematics and Statistics and the mathematics educators and students in the Department of Educational Curriculum and Instruction. He spoke to a group of approximately 50 faculty members and students about recent trends in research in the teaching and learning of mathematics. The audience of faculty and students from both departments showed the potential for future collaboration among the groups.

(2) To conduct a workshop for teaching assistants who teach in the Mathematics Department to train them on the use of alternative forms of assessment and beginning to include journal writing in the elementary teacher preparation content courses.

(3) To include guest lectures in content courses made by mathematics educators or vice-versa.

A workshop for all graduate students was not conducted. However, in the Fall Semester, 1994, a mathematics educator presented a workshop to a graduate Mathematics Education Seminar on the use of alternative forms of assessment. In the Spring Semester, 1995, in a course on education theory and practice for graduate students with teaching assistantships and no prior experience with teaching, a mathematics educator was invited to address the class on the "basics" of assessment in mathematics. Together, they explored how to write tests, what

traditional assessments do and do not tell us about students, and the value of determining more than whether or not students "got the right answer." Finally, in the Summer of 1995, an inservice program for middle school teachers on the development of algebraic thought, conducted by a member of the Mathematics Department, included a workshop-within-the-workshop delivered by a mathematics educator.

Next Steps

The 1994-95 academic year at Bowling Green State University saw considerable collaboration between members of the Mathematics Department and mathematics educators. It is our hope to continue to develop these relationships as we more carefully tie-together the goals of content and methods in the preparation of teachers. We hope to build on the successes of this year by offering co-sponsored events, collaborating on writing projects, and giving "guest lectures" in one another's classes. We also hope to extend this collaboration to additional members of both the mathematics and education departments.

Emporia State University
Emporia, Kansas

Contact person: Elizabeth (Betsy) Yanik
Division of Mathematics and Computer Science
Emporia State University
Emporia, KS 66801
Phone: (316) 341-5630
e-mail: ynaikeli@esumail.emporia.edu

Demographics Information

Type of school: Four year

Size of undergraduate student population: 6,000

Average number of graduates over the past three years:
Secondary mathematics: 15
Elementary (general): 150
Elementary (math specialist): 17
Middle Level/Junior High: 6

Course Information

A. Elementary Program
Required number of hours in mathematics: 9
Additional number of hours required for elementary specialty in mathematics: 9
Required number of hours in mathematics methods: 2

B. Middle Level/Junior High Program
Required number of hours in mathematics: 20
Required number of hours in mathematics methods: 5

C. Secondary Program
Required number of hours in mathematics: 39
Required number of hours in mathematics methods: 3

Mathematics courses in addition to those shown in table.

Required	Electives (One course from below.)
Mathematical Modeling	Mathematical Statistics
	Groups, Rings, Fields
	Vector Spaces

Institutional Focus

Emporia State University was founded in 1863 as Kansas State Normal School, the state's first school for preparing teachers. The University currently offers 50 baccalaureate degree programs, 43 Masters degree programs, and the only library and information management doctorate in an 18 state region. Emporia State continues to take pride in its long-standing tradition of excellence in teacher education. ESU has received 3 National Showcase for Excellence Awards and is a member of the Renaissance Group and Project 30, national coalitions for teacher education reform. Also the National Teachers Hall of Fame is located in Emporia with induction ceremonies held each June.

Target Objectives for the 1994/95 Academic Year

- To explore team-teaching opportunities
  We are just completing the third year of an innovative team-teaching program with our city's high school. As part of an NSF Teacher Enhancement Grant, each semester a mathematics faculty member from Emporia State University and Emporia High School team teach a course at the high school as well as at the university (one semester the exchange was with the middle school). This has led to a genuine partnership between our two schools. All participants enjoyed and valued their exchange. This unique opportunity is particularly appropriate for the university faculty, since our division's principal focus is teacher preparation.

- To include more use of technology for pre-service teachers
  We are making great strides in our effort to incorporate technology in our division's curriculum. For the past two years, we have required that all calculus students purchase a graphing calculator (TI-82, TI-85, or equivalent). We have also converted one half of our College Algebra classes to graphing calculator sections. Last year our division received an NSF Instrumentation Grant which has enabled us to create a new mathematics computing laboratory with 12 Power Mac's (6100) and a laser printer. We have purchased the following software: Maple, MATLAB, Differential Systems, Geometer's Sketchpad, True BASIC, and additional software which allows us to set up a bulletin board for class communication and private journal communication. We have changed our Calculus I and II courses from 5 one hour meetings to 4 one hour meetings with a two hour laboratory session. The computing laboratory has also been used by our students in Calculus III, Differential Equations, College Geometry, Linear Algebra, and Math Methods. We anticipate that as the faculty and students become more familiar with these software packages their use will pervade our entire curriculum.

- To develop strategies to reach students from underrepresented groups and rural populations
  This year we have hosted a number of opportunities in mathematics for Kansas students. Each October we host a Mathematics Day for high school students from the surrounding districts. Approximately 400 students, most

of whom come from rural school districts, participate in team and individual mathematics contests in algebra, geometry and pre-calculus. In addition, the Divisions of Mathematics and Computer Science, Biology, and Physical Sciences worked together to sponsor an Expanding Your Horizons conference, which is designed to increase middle school girls' interest in mathematics and science and their awareness of career opportunities in these areas. Approximately 200 girls attended and because of its success we are already planning a similar conference next year. This spring, supported by a grant from the Association of Women in Mathematics (AWM), we hosted a Sonia Kovalesky Day for 70 high school women. Currently we have a summer teacher in-service project aimed at providing summer enrichment programs for underrepresented populations.

Hastings College
Hastings, Nebraska

Contact persons: Elizabeth Behrens or David Cooke
Department of Mathematics and Computer Science
Hastings College
P. O. Box 269
Hastings, NE 68901
Phone: (402) 461-7308 or (402) 461-7418
e-mail: lbehrens@hastings.edu
dcooke@hastings.edu

Demographics Information

Type of school: Four year comphrehensive

Size of undergraduate student population: 1000

Average number of graduates over the past three years
Secondary mathematics: 3
Elementary (general): 25
Elementary (math specialist): .5
Middle Level/Junior High: Included in secondary or elementary

Course Information

A. Elementary Program
Required number of hours in mathematics: 6
Additional number of hours required for elementary specialty in mathematics: N/A
Required number of hours in mathematics methods: 3

B. Middle Level/Junior High Program
Required number of hours in mathematics: N/A
Required number of hours in mathematics methods: N/A

C. Secondary Program
Required number of hours in mathematics: 34
Required number of hours in mathematics methods: 3

Mathematics courses in addition to those shown in table.

Required	Electives
	Physics is recommended

Background

Hastings College is a four-year liberal arts college located in south central Nebraska. The department of mathematics and computer science has four full-time tenured faculty members. On average the department graduates 8 to 12 mathematics majors per year, with two to five of these completing certification requirements for secondary education. We have an occasional M.A.T. student with a specialization in mathematics and/or computer science; approximately once every three years this degree is awarded. The department of Teacher Education, housed in the same building as the mathematics offices, has four full-time tenured faculty, one three-quarter time instructor, and a number of adjunct faculty who teach specialized courses. Approximately 20 to 25 students per year graduate with elementary education certification, several of these also with supplementary endorsements in special education. We do not currently offer a middle school endorsement.

Areas Targeted for Reinforcement/Reform

(1) Increase mathematics content for elementary education majors. In the Fall of 1994 we petitioned the Teacher Education Policies Commission to include two Mathematical Foundations courses (6 semester hours) among the prerequisites for admission to Teacher Education. This change was approved, to be effective immediately for all students not already accepted into the program. A new course in Geometry Foundations was added for Spring 1995. Although enrollment in this pilot section was only eight students, the course, which emphasized manipulatives, use of Geometers' Sketchpad, and collaborative learning, was very well received, and will remain among our yearly offerings.

(2) Early practica for Prospective secondary mathematics teachers. We now are able to offer opportunities for "teaching assistantships" within our own program, allowing second- and third-year students to, for reduced credit, participate in a lower-level mathematics courses and, under the supervision of the course instructor, design and teach one or more lessons. One student signed up for this experience in Spring 1995, and gained valuable experience not usually afforded to secondary mathematics education majors by taking part in the Geometry Foundations course required for elementary education students.

(3) Increase speaking and writing opportunities/requirements in all mathematics courses. In our upper-division major courses, which have smaller enrollments, student oral presentations, both formal and informal, are common. In all courses we have increased the amount of writing expected of our students. Dr. Cooke is now requiring weekly journals of his students in his lower-division courses. Examinations in most courses typically include essay questions in addition to problems. The introduction of student projects in the calculus and differential equations courses has met with varying success in terms of quality of student work and student attitudes. Our anecdotal evidence suggests that many students, not only at Hastings College, resent "extra work" and may even regard projects, journals, computer lab exercises, etc. as "busy work". Certainly from the instructor's point of view, writing assignments place a greater burden on

the conscientious instructor who must read and respond to each individual student. Therefore, from both perspectives, we may attract as much criticism as enthusiasm until writing is perceived as a natural and necessary part of learning and using mathematics.

(4) Take advantage of communication with faculty of Teacher Education, and work for mutual understanding of the joint curriculum for training teachers. We have opened very productive dialogue with the teacher education faculty member in charge of the elementary mathematics methods course, and together we will begin work in the fall of 1995 to design a two-semester 8-10 semester hour integrated course incorporating both content and methods of elementary school mathematics. With a new faculty member coming on staff in science education, we hope to work for even broader course development and implementation, integrating science and mathematics.

Illinois State University
Normal, IL

Contact Person: Roger Day
Mathematics Department
Campus Box 4520
Illinois State University
Normal, IL 61790-4520
Phone: (309) 438-8781
e-mail: day@math.ilstu.edu

Demographics Information

Type of school: Comprehensive

Size of undergraduate student population: 16,483

Average number of graduates over the past three years:
Secondary mathematics: 23
Elementary (general): 251
Elementary (math specialist): 31
Middle Level/Junior High: 21

Course Information

A. Elementary Program
Required number of hours in mathematics: 6
Additional number of hours required for elementary specialty in mathematics: 18
Required number of hours in mathematics methods: 3

B. Middle Level/Junior High Program
Required number of hours in mathematics: 30
Required number of hours in mathematics methods: 3-6 hours included in the 30 hours.

C. Secondary Program
Required number of hours in mathematics: 40
Required number of hours in mathematics methods: 6 hours included in the 40 hours

Mathematics courses in addition to those shown in table.

Required	Electives
	Technology-Extended Mathematics for Secondary Schools

Mission Statement

Illinois State University is the oldest higher education institution in Illinois and has a student body of nearly 20,000. The Mathematics Department has 31 full-time tenure-track faculty and 51 faculty in all to serve a broad segment of the undergraduate population. There are 250 undergraduates who major in mathematics, more than half of whom are preparing for secondary mathematics teaching. Illinois State University prepares more secondary mathematics teachers annually than any other institution in Illinois. There are also more than 250 elementary and junior high/middle school education majors who claim mathematics as an area of specialization. The department provides all mathematics content and methods course work for these students. In addition to programs for prospective elementary, middle school, and high school teachers of mathematics, the department offers a special program of inservice education for practicing teachers as well as masters and doctoral programs in mathematics education.

Key Areas Targeted For Change: Academic Year 1994-1995

Area A: The need to provide secondary mathematics majors earlier exposure to and interaction with the mathematics education faculty and with issues of mathematics education.

Proposed Action: During Fall Semester 1994, develop an experimental sophomore/junior-level mathematics education course for potential majors. Offer the course Fall Semester 1995.

Action Undertaken: The secondary mathematics education faculty designed a one-credit nonrequired experimental course to address this need. The course was approved by the department and the college and has been offered for the first time during fall semester 1995. The aim of the new course is to engage students early in their academic program in thinking deeply about and reflecting on teaching and learning mathematics.

Next Steps: The evaluation plan of the project funded under Area C (below) includes plans to monitor the effects of this course and other components of the secondary majors' program. A mathematics Ph.D. student is focusing her dissertation research on the impact of the course upon its participants.

Area B: The need to provide reform-based instruction in mathematics courses taken by prospective teachers.

Proposed Action: Beginning Fall Semester 1994, conduct a collaborative faculty seminar on the teaching and learning of reform calculus to involve both mathematicians and mathematics educators.

Action Undertaken: Calculus instructors conducted a weekly seminar on the teaching and learning of reform calculus. Weekly discussions focused on de-

partment use of the calculus text developed by the Calculus Consortium at Harvard (CCH). Academic year 1994-1995 marked the first year that the CCH materials were used in all sections of first- and second-semester calculus.

Seminar participants were surveyed in May 1995. Respondents identified the seminar as a means for sharing concerns about and support for teaching the course. Seminar discussion was helpful for gauging the pace of instruction, for scheduling of exams and other course components, and for sharing projects, problems, and other course activities.

Aspects of the seminar identified as disappointing were that the week-to-week concerns of running the course got in the way of in-depth discussion of course pedagogy; there was little discussion of both how to approach specific topics and the clear establishment of expectations for student performance; there was a lack of seminar participation by other members of the department and a failure to extend the seminar to other multi-section courses affected by the calculus sequence.

Next Steps: Suggestions for improving future seminars included doing a better job of developing goals and expectations for the course and for specific content within the course. Over time, the seminar could help to generate a file of good projects for student use as well as a solid timetable for sequencing the course. As more faculty members gain experience with reform calculus, the seminar could move away from discussing scheduling and other logistical concerns to focus more on pedagogy, the use of projects, and the discussion of other substantive course components and issues.

Area C: The need to upgrade and expand the department computer laboratory in order to help provide a richer environment for technology immersion for prospective teachers.

Proposed Action: During Fall Semester 1994, submit to the National Science Foundation (NSF) an Instrumentation and Laboratory Improvement—Instrumentation Projects (ILI-IP) equipment proposal designed to help bring the existing department computer laboratory closer to a state-of-the art facility for teaching and learning mathematics.

Action Undertaken: Three members of the department submitted an ILI-IP proposal to the NSF. The proposal, entitled Project PreEMPT Tech: Preparing Effective Mathematics Preservice Teachers With Technology, requested resources necessary to create a networked computer laboratory for mathematics education.

The project was funded in June 1995 and will offer developing mathematics teachers an environment within which they can gain early and substantial experience with technology for teaching and learning mathematics. The networked computer laboratory will be used within several courses in the sec-

ondary majors' program to broaden and enrich secondary majors' mathematical explorations.

Next Steps: The dissemination and evaluation plan of the project includes plans to monitor the effects of laboratory availability and use within the secondary majors' program.

Area D: The need to revise the mathematics course for elementary teachers to reflect the new general education requirements of the university.

Proposed Action: During the academic year 1994-95, develop a course for the new general education literacy requirements that also serve for preservice elementary teachers.

Action Undertaken: The course *Dimensions of Mathematical Understanding I* has been proposed as one of four general education mathematics literacy courses. It has been approved by the department and by the university general education pilot committee. The initial pilot offering of the course is scheduled for Spring Semester 1996.

Funding for course development has been received as part of an NSF grant. During summer 1995, an ISU professor, a community college professor, and two secondary teachers met to discuss the development of the course. An internal funding request has been made to support an ISU professor in developing materials. In addition, a Course and Curriculum Development (CCD) grant proposal was submitted in June 1995 to the NSF. The proposal requests funds to support further development of the course and its follow-up *Dimensions of Mathematical Understanding II*. The proposal includes plans for assessment and dissemination of the information generated through the course development process.

Next Steps: Funding requests are being monitored as course development continues. An unanswered question is whether the goals and needs of preservice elementary teachers will be met if a course meets in large-lecture sections, a proposal currently under consideration for *Dimensions of Mathematical Understanding I*.

Kansas State University
Manhattan, Kansas

Contact person: Williard A. Parker
Department of Mathematics
Cardwell Hall
Kansas State University
Manhattan, KS 66506
Phone: (913) 532-6750
e-mail: parker@math.ksu.edu

Demographics Information

Type of school: Doctoral

Size of undergraduate student population: 20,000

Average number of graduates over the past three years:
Secondary mathematics: 20
Elementary (general): 285
Elementary (math specialist): 33
Middle Level/Junior High: 50
(Also counted as either elementary or secondary.)

Course Information

A. Elementary Program
Required number of hours in mathematics: 9
Additional number of hours required for elementary specialty in mathematics: 21
Required number of hours in mathematics methods: 3

B. Middle Level/Junior High Program
Required number of hours in mathematics: 24
Required number of hours in mathematics methods: 3

C. Secondary Program
Required number of hours in mathematics: 34
(Plus statistics and computer science.)
Required number of hours in mathematics methods: 3

Mathematics courses in addition to those shown in table.

Required	Electives
	Finite Math

Concern

Mathematics graduate students, most of whom will take teaching positions, are unfamiliar with many aspects of college teaching, especially of various reforms in the teaching of college mathematics.

Proposed Approach
We would offer a three hour graduate course in the mathematics department on teaching college mathematics.

Action Taken
In the spring semester of 1995, the course MATH 896 *Topics in Mathematics: Teaching College Mathematics* was taught by Bill Parker. Nine graduate students in mathematics took the course for three hours credit. Originally we were concerned that the course would not be approved by the mathematics department but the opposite was the case. The course dealt with issues of curriculum, advising, teaching, and evaluation. Course work involved a good deal of reading, especially of various MAA publications; presentations by several mathematics department faculty and by graduate students (both enrolled and not enrolled in the course), and lively discussions. One outcome of the course was a new evaluation form for graduate student teaching that has been submitted to the department. The course seems to have been quite successful.

Next Steps
There is interest by the department head and some faculty in seeing that our graduates are prepared to teach mathematics. The *Teaching College Mathematics* course will most likely be offered again in several years. In addition graduate courses directed toward specific aspects of teaching college mathematics such as the use of technology in teaching mathematics will most likely be taught. However, it appears this will depend on individual faculty members initiating such courses and on graduate students interest in taking the courses.

Concern

Preservice secondary mathematics teachers are unaware of changes, especially reforms, in school mathematics curriculum and pedagogy as well as other issues related to the profession of teaching in Kansas.

Proposed Approach
We would offer a one hour course dealing with these issues, ideally for freshmen or sophomores.

Action Taken
In the fall of 1994, John Dalida and Bill Parker taught an orientation course for prospective mathematics teachers. The course met weekly for one hour in the student union. Four students attended at least some of the meetings and two students who took the course for credit attended all the meetings. Topics included national and state curriculum standards and professional teaching

standards, outcomes based education and state Quality Performance Assessment, state mathematics assessment, gender and equity issues, and the new Kansas requirements for beginning teachers. Students taking the course for credit were required to visit schools, make observations, and interview teachers and councillors.

Next Steps
In general we felt this course was a good experience for the students who attended. They were however juniors and we had intended the experience for freshman or sophomores. To be successful with this course, we believe it needs to be a required course in the secondary mathematics education curriculum, perhaps as a sophomore level course. Since Professor Dalida will be on sabbatical next year and since other curriculum changes for the secondary mathematics education major are in order because of the changes in state licensing of beginning teachers, we did not attempt to initiate changes this year.

Concern

Beginning secondary mathematics teachers, in their first year of teaching, tend to be isolated and are often overwhelmed by their responsibilities.

Proposed Approach
Support for beginning school teachers of mathematics including a newsletter, site visits, email and phone networks, and a survival kit.

Action Taken
A few visits to beginning teachers were made by John Dalida but we came nowhere near accomplishing our plan.

Next Steps
We still think this is a good idea but simply ran out of time to do it. Since Professor Dalida will be on sabbatical in Russia next year, (1995 - 1996) and Professor Parker the following year it is unlikely that we will be able to carry out this part of the plan in the near future.

Mayville State University
Mayville, North Dakota

Contact Person: Richard G. Holman
Mayville State University
330 3rd Street NE
Mayville, ND 58257
Phone: (701) 786-4730
Fax: (701) 786-4890
e-mail: rholman@plains.nodak.edu

Demographics Information

Type of school: 4 year

Size of undergraduate student population: 800

Average number of graduates over the past three years:
Secondary mathematics: 12
Elementary (general): 50
Elementary (math specialist): 10
Middle Level/Junior High: N/A

Course Information

A. Elementary Program
Required number of hours in mathematics: 9
Additional number of hours required for elementary specialty in mathematics: 9
Required number of hours in mathematics methods: 3

B. Middle Level/Junior High Program
Required number of hours in mathematics: N/A
(North Dakota requires College Algebra for an elementary teacher to teach grades 7-8.)
Required number of hours in mathematics methods: N/A

C. Secondary Program
Required number of hours in mathematics: 40
Required number of hours in mathematics methods: 3

Mathematics courses in addition to those shown in table.

Required	Electives
	Mathematics Seminar
	Special Projects

Institutional Mission Statement

- To provide instructional programs at the baccalaureate level for teachers in elementary and secondary schools.
- To provide instructional programs which prepare students for transfer into graduate programs at other institutions.
- To provide a general education program which assists students in the development of communication and critical thinking skills for effective functioning in modern society.
- To provide a climate that meets the individual and group needs of a diverse and pluralistic society.
- To provide educational programs which assist in the transition from school to higher education.
- To provide the type of service which will best serve the needs of the local community, the surrounding area and the region.

Discussion of Institutional Approach

Concern to be Addressed

A need exists for the increased use of technology by both faculty and students. Along with that is a need for faculty, staff, and student training.

Approach to Meet the Concern

All faculty in the Division of Teacher Education have office access to the internet through access to the North Dakota Higher Education Computer Network. An institutional goal is that all campus faculty will be so equipped by 1996.

Mayville State University (MaSU) is a participant in a U.S. West Foundation Grant for equipment and training necessary for faculty and education students to learn how to use multimedia for classroom presentations. This is a collaborative effort with Valley City State University (VCSU) and North Dakota State University.

MaSU and VCSU have received a five year grant from Title III (Department of Education) to integrate technology and cooperative learning for instructional purposes. This will involve faculty and students.

Currently being studied is a proposal for all faculty and students to be equipped with laptop computers by the fall semester of 1996. Training would be an integral part of this program.

All faculty have access to the Center for Innovation in Instruction at Valley City State. This is a multimedia resource center supported by the North Dakota University System (NDUS).

A faculty, staff, student committee for the improvement of technology meets monthly to discuss the future of technology at MaSU.

Action Taken and Evaluation of the Effect

All of the above have given a good start to increasing the role of technology at MaSU. Most faculty are committed to increasing their use of technology and are willing to learn how to use it to enhance their instruction. Both the President and the Vice President for Academic Affairs are committed to finding ways to increase the use of technology by students and faculty. The NDUS is financially supportive and has made all public and tribal colleges in North Dakota a part of the Higher Education Computer Network.

Next Steps

Efforts will be made to collaborate with elementary and secondary schools to help them train their faculty in the use of multimedia technology for instruction. Efforts will continue to secure funding and time for faculty and student training in the use of technology.

Metropolitan State College of Denver
Denver, Colorado

Contact Person: Joseph A. Raab
Campus Box 24
Metropolitan State College of Denver
P.O. Box 173362
Denvers CO 80217-3362
Phone: (303) 556-4242
e-mail: raab@zeno.mscd.edu

Demographics Information

Type of school: Four-year undergraduate

Size of undergraduate student population: 16,815. Fall 1995.

Average number of graduates over the past three years:
Secondary mathematics: 15
Elementary (general): 260
Elementary (math specialist): 18
Middle Level/Junior High: N/A

Course Information

A. Elementary Program
Required number of hours in mathematics: 4
Additional number of hours required for elementary specialty in mathematics: 39
(Students must satisfy requirements for a major in mathematics.)
Required number of hours in mathematics methods: 4
(Combined mathematics and science methods.)

B. Middle Level/Junior High Program
This program does not exist now, but is being worked on.

C. Secondary Program
Required number of hours in mathematics: 39
Required number of hours in mathematics methods: 3

Mathematics courses in addition to those shown in table

Required	Electives
	Introduction to Mathematics Proofs
	Senior Experience
	Mathematics Seminar

Institutional Focus

Metropolitan State College of Denver is the largest public, four year baccalaureate-degree granting urban college in the United States. Since commencing operations in 1965, the college has contributed to the vitality of metropolitan Denver. From 1000 students and 35 faculty in 1965, the college has grown to approximately 18,000 students and over 800 full and part-time faculty. Offering baccalaureate degrees in over 50 areas, the college's impact on the community continues to increase, and its partnership with the Denver area is continually reinforced. This partnership includes a growing involvement in public schools on the part of faculty, and as the second largest producer of majors in education in the state, on the part of its graduates as well.

A. The Teacher Education Program at MSCD

The program separates naturally into two components: Those who are mathematics majors with a secondary education emphasis, and those who are in the elementary and middle school program. There were 17 graduates in the 1993-94 academic year (out of 49 mathematics majors) in the secondary education emphasis. The number of elementary and middle school graduates is harder to gauge, since there is no "elementary education" major in Colorado, hence these students must major in an academic field, with additional training in educational theory and practices, plus student teaching field experience. The only way to track them is to count the number seeking state accreditation, and the college does not keep records of that.

The secondary emphasis mathematics major is required to take a standard major with some special requirements aimed at teaching. These courses include the following: (All credits are semester hours.)

Calculus I, II, and III (each 4 hours)
Introduction to Mathematical Proofs (3)
Linear Algebra (3)
Abstract Algebra I (3)
Introduction to Geometry (3)
One "computer" course (3)
History of Mathematics (3)
Methods of Teaching Secondary Mathematics (3)
Probability and Statistics (3)
Upper division electives to total at least 36 hours.

There is one semester of student teaching field experience under the supervision of a cooperating school teacher and an observer from the Division of Professional Education. This field assignment is contingent upon a 2.75 grade point average in mathematics on a scale of 4.00 and the recommendation of the mathematics department's Secondary Education Committee.

The elementary and middle school accreditation students are required to take one course in mathematics taught in the mathematics department by mathematics faculty. This, of course, is Mathematics for the Elementary School.

There are some mathematics faculty who have specialized in education and who teach this course. The course is sort of a combination of content and method. Later in this report it will be seen that significant changes to the approach in this course have occurred.

B. Issues Undertaken

- Reform mathematics instruction for education students to address such issues as cooperative, hands-on, problem-centered, integrated approaches to teaching and learning.

- Encourage mathematics faculty to participate in schools, and to utilize alternative approaches to undergraduate mathematics instruction in general.

- Cause admissions policy reform at the collegiate level reflecting increasing school emphasis on content standards, alternative methods of assessment, and creative instructional frameworks.

C. Progress Report

Efforts to reform mathematics instruction for education students have been centered around and driven by a funded five-year NSF grant: Rocky Mountain Teacher Education Collaborative (RMTEC) which includes the University of Northern Colorado, Colorado State University, and Metropolitan State College of Denver. This grant aims at the reform of science and mathematics education for pre middle-school and secondary school students at the three institutions. Each institution will emphasize a specific discipline for intense scrutiny for each of the five years of the grant. For example, 1994-95 was MSCD's year for mathematics, and 1995-96 will be MSCD's year for physics. In this way, each school will examine each of the five disciplines: mathematics, physics, chemistry, biology, and earth sciences. During any one year three different disciplines will be under scrutiny by RMTEC.

Through the dedicated work of education specialists in the MSCD mathematics department, and of a master teacher from Cherry Creek Schools, hired for this purpose through the grant, significant reform has occurred in mathematics classes for education students. Instruction has been heavily dominated by hands-on, problem solving, group learning approaches to mathematical content and ideas. At the same time, these activities have focused on how these modes of instruction apply to the future classrooms of the students as teachers.

Students who have been placed in schools for their student teaching field experience have been very carefully paired with "sympathetic" supervising teachers in the schools who are already using the new methods being discussed in collegiate classes. In addition, personnel from the RMTEC grant have observed the student teachers in teaching settings and made evaluations focusing on the new instructional methods.

Success in getting mathematics faculty in general involved in schools has been mixed. Through the MSCD Visiting Scientist Program several faculty

have volunteered in a variety of ways in the schools, but the volunteers in general are recruited from all possible sources, not just from academia. Another avenue for faculty involvement has been through another NSF-funded program, the statewide systemic initiative CONNECT. There are three faculty and administrators from MSCD working with the Denver-CONNECT Collaborative (one of twelve state-wide) which includes a cadre of coordinators from eight pilot schools of Denver Public Schools (DPS). The objective of this grant is to initiate the implementation of content standards and assessments in science and mathematics K-16. There is a state law HB 94-1313 which mandates the introduction of content standards in eight disciplines in each of the 176 districts in the state which meet or exceed state model standards. MSCD and DPS have offered a variety of workshops and seminars which focus on new methods of instruction assumed to go hand-in-hand with standards, and these are the same methods being addressed by RMTEC. Some MSCD faculty have been involved in Denver CONNECT, but not as many as needed. The problem is, such involvement has not historically been a prominent part of the evaluation process for faculty. It is hard for them to see the benefit of doing something for free which would take away from activities which are recognized for merit.

Success in modifying admissions policy to reflect student experience in content standards and alternative assessments, to say nothing of alternative learning styles has been even more mixed. There are some institutions in the state that are beginning to consider such modifications. In a meeting of collegiate persons from around the state involved in teacher education activities (held at Colorado State University), the issue of admissions policy change was one of the problems discussed among several others needing reform in teacher education. To date, there has been no specific public statement from any institution of higher education in the state which announces such a policy change.

C. Next Steps for MSCD

The most important issue facing us, which is nowhere near resolution, is that of admissions policy reform to reflect changes in the schools. It is the intent of RMTEC and CONNECT personnel to have a series of discussions with admissions directors and staff in an attempt to change policy, and to have such policy changes announced publicly. Such public statements will strengthen the hand of those working for standards-related reforms in the schools.

As far as CONNECT is concerned, the experience of the pilot schools in 1994-95 in implementing standards will be reported to DPS standards groups for their use and information. Following that, a two-week institute will be offered by MSCD/DPS June 12-23 for pilot school teachers on the translation of content to classroom ready modules which address standards.

Minot State University
Minot, ND

Contact person: James Babb
Mathematics Department
Minot State University
500 University Avenue West
Minot, ND 58707
Phone: (701) 858-3075
e-mail: babb@warp6.cs.misu.nodak.edu

Demographics Information

Type of school: Comprehensive

Size of undergraduate student population: 4000

Average number of graduates over the past three years:
Secondary mathematics: 9
Elementary (general): 180
Elementary (math specialist): N/A
Middle Level/Junior High: N/A

Course Information

A. Elementary Program
Required number of hours in mathematics: 9
Additional number of hours required for elementary specialty in mathematics: N/A
Required number of hours in mathematics methods: 3

B. Middle Level/Junior High Program
Required number of hours in mathematics: N/A
Required number of hours in mathematics methods: N/A

C. Secondary Program
Required number of hours in mathematics: 35
Required number of hours in mathematics methods: 6

Mathematics courses in addition to those shown in table.

Required	Electives

Institution Mission/Focus Statement

Minot State University is a comprehensive public university with 4000 undergraduate and 500 masters-level students. Founded in 1913 as Minot Normal School, MSU has evolved into a comprehensive university. MSU is located in Minot, North Dakota, a city of 35,000 that serves as the cultural, educational and commercial center of a region which includes western North Dakota, eastern Montana, and southern Saskatchewan and Manitoba. Minot is situated in one of the richest agricultural, industrial and commercial areas in the state. The city is near the Garrison Dam on the Missouri River which offers world-class outdoor recreational opportunities in fishing, boating, sailing, hunting and camping. The University affirms its traditional roles in the areas of education and human services, where students prepare for professions aimed at improving the quality of life for all people. Minot State University is a full partner in the North Dakota University System (NDUS), the lawfully empowered system of higher education for the state.

Concerns/Actions Taken

1) Upgrade admission procedures for Teacher Education (especially Elementary Education).

While it didn't seem that anything could be done about the admission procedures for education (especially elementary!) a change in the Chairperson for the Dept of Education has improved our position there. The new chair, while she hasn't changed the requirements for admission is not granting the many exceptions that were common in past years. Presently, El Ed majors are required to take a 4 hour course in College Algebra (general education), a 5 hour course in math for elementary teachers and a 3 hour course in math methods (which has a 55-hour practicum as part of the course). I have talked to the chairperson about the mathematics course requirements and am in the process of discussing splitting the one 5 hour elementary content course we now require into two 3 hour courses.

2) Expand the integration of manipulatives, calculators, and computers into the Mathematics courses for Elementary Education.

We have incorporated a complete series of computer programs written in LogoWriter into our Elementary Math course. The students are asked to type in several programs involving counting, basic facts drill, probability data generating programs, and even some fractal drawing things. After they get them to work we talk about them and even have the students make some changes in them. It is certainly not a full-fledged programming course but it does give them enough knowledge of Logo to make them dangerous! A booklet of programs, keyed to their texts, is in the final stages of development in the department.

We have developed some lab activities, borrowed others, and are working on developing more which are required of students both in and out of class to show them how to teach with manipulatives (pattern blocks, geoboards, etc).

We require students to purchase a Math Explorer Plus calculator and we use it in class a lot. The students think it's fine for them to use these calculators but several don't think children should be allowed to use them "Until they master the BASICS" (whatever that means!). We are still working on that!

3) Expand the integration of manipulatives, calculators, and computers into the courses for Secondary Mathematics Education.
Secondary Mathematics Education majors are now using computers in their Geometry class. They learn how to use the Geometer's Sketchpad and do a bit of work with LogoWriter. They also are using Miras to do some HS-level constructions (trisecting an angle, constructing bisectors, etc.). The use of calculators is presently not very well done. Most students seem to get all the way to Math Methods class without even using a graphics calculator and have no idea of how or why we should be using them in secondary schools. We need to find a way to get calculator use into our college mathematics classes (or somewhere) so students have exposure to calculators in a teaching setting and know something about them when they get to methods class.

4) Incorporate more field experiences into Secondary Mathematics Education.
The secondary methods class had a short (5-10 hour) practicum this year. We used to have practicums every semester at a Catholic High School across the street and then our state board decided we couldn't cooperate with such schools (church and state separation, you know). Since it wasn't convenient to go to the public High School we dropped the practicum for several years. We are now trying to put it back in and expand it and are planning on going to 15-20 hours next year.

Another thing we are working on for next year is to put some more specific requirements into the 10 hour 'shadowing' requirement students have in their Introduction to Education class everyone has to take as a first education class. The requirements are pretty loose now (do whatever the teacher wants you to do), and we would like to put in some specifics, such as observe a class taught with the graphics calculator, grade some papers that require partial credit, deal with a general ed math class, and other specific things they should know about later.

Montana State University Bozeman, MT

Contact person: Ted Hodgson
Department of Mathematical Sciences
Montana State University
Bozeman, MT 59717
Phone: (406) 994-5350
e-mail: Hodgson@mathfs.math.montana.edu

Demographics Information

Type of school: 4 year Doctoral

Size of undergraduate student population: 11,000

Average number of graduates over the past three years:
Secondary mathematics: 15
Elementary (general): 120
Elementary (math specialist): N/A
Middle Level/Junior High: N/A

Course Information

A. Elementary Program
Required number of hours in mathematics: 8
Additional number of hours required for elementary specialty in mathematics: 9
Required number of hours in mathematics methods: 3

B. Middle Level/Junior High Program
Required number of hours in mathematics: N/A
Required number of hours in mathematics methods: N/A

C. Secondary Program
Required number of hours in mathematics: 40
Required number of hours in mathematics methods: 3

Mathematics courses in addition to those shown in table.

Required	Electives
Physics	Several courses in applied mathematics are optional.

Institutional Mission/Focus Statement

Montana State University is a four-year public, comprehensive, land-grant university with undergraduate and graduate programs in liberal arts, basic sciences, the professional areas, agriculture, architecture, business, nursing, education, and engineering. Although the traditional missions of the school are agriculture and engineering, the school is now the largest producer of certified public school teachers in the state of Montana. As part of its effort to provide a quality contemporary education, the teacher preparation programs in mathematics and science are currently being reviewed and revised. These revision efforts are supported by a Teacher Collaborative Grant from the National Science Foundation.

Institutional Approach

1. (a). Student teaching environments often fail to support and encourage experimentation with alternative approaches to mathematics teaching.
   (b) Eight model field sites schools in which teachers support and implement educational reform will be selected and receive student teachers.
   (c) Eight model school sites (and "lead" teachers at these sites) were selected and received student teachers. Three workshops for teachers and administrators were held to ready schools for student teachers and provide support for schools during the student teaching assignment.
   (d) The use of model field sites will continue to be assessed and developed.

2. (a) Content and methods courses taken by pre-service mathematics teachers often fail to model contemporary reforms in mathematics teaching.
   (b) We will identify competencies that reflect the recommendations of leading educational institutions and develop courses that allow students to achieve these competencies.
   (c) In sum, reforms were implemented in Calculus, matrix theory, mathematics for prospective elementary teachers, and methods courses at the elementary and secondary levels.
   (d). We will continue to refine "reformed" courses and overhaul our entire program of mathematics courses designed for pre-service secondary teachers.

3. (a) The rural nature of Montana forces teachers to teach multiple subject areas and effectively isolates teachers. This is especially problematic for new teachers.
   (b) We will develop models to prepare and support teachers for rural school settings.
   (c) We developed early career "survival" kits for teachers entering rural schools in Fall, 1995 and initiated the establishment of a state-of-the-art telecommunications network to provide professional support for these teachers.
   (d) We will draw upon the work of our Early Career Support Committee for additional solutions.

4. (a) There is a critical shortage of minority (especially Native American) and women teachers.
   (b) We will recruit and support talented women and minority pre-service teachers and institute programs in Montana's two-year Tribal Colleges to attract and retain Native American teachers.
   (c) We awarded scholarships to pre-service mathematics and science teachers. Although all students were eligible for the awards, priority was given to women and Native American students. Other activities include the founding of the Native American Peer Advising Program, the establishment of a Tribal College Summer Academic Bridge program, and summer institutes for teacher educators at the Tribal Colleges.
   (d) In cooperation with the Tribal Colleges, we will develop mathematics courses for prospective Native American teachers.

Northwest Missouri State University
Maryville, MO

Contact person: Cheryl Gregerson Malm
Department of Mathematics and Statistics
224 Garrett-Strong
Northwest Missouri State University
Maryville, MO 64468
Phone: (816) 562-1206
e-mail: 0100211@acad.nwmissouri.edu

Demographic Information

Type of School: Comprehensive

Size of undergraduate student population: 6000

Average number of graduates over the past three years:
Secondary mathematics: 10
Elementary (general): 120
Elementary (math specialist): 18
Middle Level/Junior High: (New program)

Course Information

A. Elementary Program
Required number of hours in mathematics: 6
Additional number of hours required for elementary specialty in mathematics: 21
Required number of hours in mathematics methods: 3
Additional required number of hours in methods required for elementary specialty in mathematics: 0

B. Middle Level/Junior High Program
Required number of hours in mathematics: 30
Required number of hours in mathematics methods: 3

C. Secondary Program
Required number of hours in mathematics: 45
Required number of hours in mathematics methods: 3

Mathematics courses in addition to those shown in table.

Required	Electives

Institutional Focus

Northwest Missouri State University is a coeducational, primarily residential, regional university offering a broad range of undergraduate and selected graduate programs. The University's programs place special emphasis upon agriculture, business, and teacher education, particularly as these professions contribute to the primary service region. All of the University's programs build upon comprehensive general education requirements. Northwest strives to provide a quality living-learning environment which will equip the individual for responsible participation in a diverse and rapidly changing society. The University places importance on developing each student's self-understanding, encouraging creative self-expression and stimulating continuing intellectual curiosity to develop a flexible, self-renewing learner who will function effectively in a global society.

Concern

There exists a significant duplication of instruction in regards to the general educational content ideas addressed in the elementary mathematics and science courses. Because of this duplication of instruction, no time is available to explore additional content specific materials.

Proposed Approach

Structure the elementary mathematics and science methods courses as a two-hour block, requiring students to complete these two courses simultaneously.

Action Taken and Evaluation

During the 1994-95 academic year, the required mathematics and science methods courses for elementary education mayors were integrated into a two-hour block by scheduling these two courses back to back. Students are required to complete these two courses simultaneously. Logistically, this coordination of the courses has worked well. The small groups assigned to each grade level for the practicum experience is the same for both mathematics and science. In this way, the college students have only one group with which to work to develop the learning cycles they teach during their two-week practicum session. We have encountered some organizational problems in implementing this scheduling change. Some students had already completed one or the other of the methods courses. This problem is working itself out, however, as those students operating under the old system graduate and the current students adjust their schedules accordingly. There were also some scheduling conflicts that had to be worked out with the teachers in the campus elementary laboratory school. It was necessary for each of them to restructure their day to insure that mathematics and science were taught at the same time as the college courses in order to allow the college students to complete their practicum during class time. All of these scheduling problems seem to have been dealt with by the spring semester.

The content covered in the mathematics and science methods courses has also been adjusted to eliminate duplication. Discussion of general issues such as

alternative assessment techniques, questioning in the classroom, and equity in the classroom has been divided between the two courses. Students are held accountable for utilizing all such information in both courses. However, as they are taught in conjunction with one another, this has not presented a problem. Dividing up the responsibility for addressing these general issues has allowed additional content specific material to be introduced into both courses. The instructors of the course have also worked as a team to model integration of mathematical and science concepts when the material permits.

Plymouth State College
Plymouth, NH

Contact Person: Bernadette Russek
Department of Mathematics
Plymouth State College
Plymouth, NH 03264
Phone: 603-535-2857
e-mail: brussek@oz.plymouth.edu

Demographic Information

Type of School: Comprehensive

Size of undergraduate student population: 4300

Average number of graduates over the past three years:
Secondary mathematics: 5
Elementary (general): 110
Elementary (math specialist): N/A
Middle level/junior high: 5

Course Information

A. Elementary Program
Required number of hours in mathematics: 10
Additional number of hours required for elementary specialty in mathematics: N/A
Required number of hours in mathematics methods: 2
Additional required number of hours in methods required for elementary specialty in mathematics: N/A

B. Middle Level/Junior High Program
Required number of hours in mathematics: 33-39
Required number of hours in mathematics methods: 7

C. Secondary Program
Required number of hours in mathematics: 37
Required number of hours in mathematics methods: 9

Mathematics courses in addition to those shown in table.

Required	Electives
Calculus IV	Computer Science is recommended
Non-Euclidean Geometry	
History of Mathematics	

Institutional Focus

Plymouth State College is a four-year liberal arts college located in central New Hampshire. Although situated in a rural setting, it is only a few hours from Boston, MA; Portland, ME; and Hartford, CT. Plymouth has a historical commitment to educating teachers, however, it is now a liberal arts college offering various degrees including a Bachelor of Science and Master of Education. Education programs are accredited by the National Council for The Accreditation of Teacher Education (NCATE).

The mathematics department has thirteen full time faculty members. It offers programs leading to both the BA and BSc in mathematics with options in actuarial, applied, computing and technical management, and mathematics education. On average, the department graduates 13 to 15 mathematics majors per year, two-thirds of these with a major in mathematics education.

Concerns addressed:
The Elementary Education Program

- To revise, change, and improve the elementary education program. To plan and implement a 12-credit hour sequence that offers an integrated experience of mathematics content, technology use, and pedagogy. This needs to be a coherent curriculum that introduces technology and teaching issues early in the "content" courses and carries this integration through the program consistently and without needless repetition.

Actions Taken

The Elementary Education Program is housed in the Education Department. However, in the last three years, the Mathematics Department has taken a major role in strengthening that program. Designing two new mathematics courses, the mathematics component is now a four semester sequence consisting of Problem Solving, Number Systems, Geometry and Probability & Statistics, and Learning Mathematics. The full sequence was put in place in Spring 1995. There is still much fine-tuning to do, but we are very excited about the strength and scope of the mathematics component of this elementary education preservice experience.

The students begin their program with Problem Solving. Employing the graphing calculator, this course provides an in-depth study of problem solving strategies and tools. Furthermore, the course provides experience with project type problems in various topic areas, particularly science. Cooperative learning is introduced and a Portfolio Assessment is suggested as one of the assessments to use in the course.

The Number Systems and Geometry and Probability & Statistics courses are primarily content courses with some imbedded pedagogical experiences, such as journal writing, textbook evaluations, journal article reports, and labora-

tory activities. Learning Mathematics is a capstone experience, integrating content, methods, theory, and fieldwork.

This new sequence was galvanized by the recent changes in the New Hampshire requirements for certification. There are no longer elementary education majors, but "Early Childhood" or "Childhood Studies" majors. This shift has spurred a number of changes that would not have occurred, or perhaps, would not have occurred as quickly.

Putting this program into place has been an on-going and bumpy process. We have selected a new text that is planned to serve for the first three courses in the series. We are in process of redistribution of the 12 credits, some rearrangement of the topics, and some revisions in the course titles. The Problem Solving and Methods courses are still being defined and honed. We are delighted to have a problem solving course and can see that the approach is a challenging experience for our teachers as well as for our students.

There are a number of difficulties to surmount with the Problem Solving offering. This double objective has caused some heated discussion in the department on the content of the course. One group wants it to fulfill traditional algebra requirements. A second group sees it as "a course whose time has come," reflecting the NCTM *Standards* by using technology, cooperative learning, and a project approach. Use of the graphing calculator is still being reviewed and discussed. Some people feel it is essential to introduce the graphing calculator; others are concerned with issues surrounding the use of such a complex and expensive tool. The issue that traditional algebra techniques may be sacrificed with calculator use also rages on.

Use of the graphing calculator has been a problem, both in procurement and in classroom management. Major issues are: Can we require students to buy such an expensive calculator? Should we strongly recommend one brand in particular? How much time and energy does learning to use a graphing calculator take away from learning the mathematics? At this time a number of the faculty has been providing the students with departmental calculators. This poses a management problem, a security problem, and lack-of-a calculator-to-do-homework problem. All of these issues remain under discussion.

We also find that we are severely short of faculty who can or will teach these courses. It is difficult to find faculty who have clear understanding of the objectives of such a program and who can carry out these objectives. Furthermore, because this is a new set of required courses for Childhood Studies and Early Childhood Studies majors, we anticipate opening about six additional sections. Our greatest concern is the staffing of these sections.

Finally, we suffer some scheduling and equipment problems. These are minor, but sufficient to warn us to think ahead as the numbers of students increase in the program. These are areas that need planning. We also have

found, due to rapid growth, that we need to get together as a faculty more often to discuss these issues. In the past, plans and decisions were made in an informal manner. To clarify objectives and have a consistent and cohesive program, we see the need to communicate more with one another. We do need to look at an assessment plan.

We feel we have made great progress and are excited about the way things are moving. More students than we anticipated opted for these courses—even though it is not a requirement for them under their present programs. A number of students have commented that is a "strong" program and feel that it will be valuable to them as they seek to become teachers.

Next Steps
Continue to work on improved communication among all the faculty involved —mathematics, mathematics education, and education.

Concerns addressed: The Secondary and Middle School Program

- To address an NCATE concern that this population does not have adequate pre-internship field experiences.

- A discrepancy exists between what we want our students to do when they go out to teach and the manner in which they are being taught. In a recent poll conducted in a junior level class, it was discovered that not one student had used either the graphing calculator or computer in their learning of mathematics. The middle school majors had taken courses that used cooperative learning activities in class. None had experienced portfolio assessment or other alternative assessment strategies.

Action Taken
To address the first concern, we are offering an experimental course "Mathematics Activities Center Internship." This course requires students to have a 20 hour internship at the Mathematics Activity Center early in their academic program. No action has been undertaken at the present to address the second concern.

Next Steps
Both of these concerns require further study. We need to identify exactly what pedagogical and field experiences this group of students encounter in their mathematics and education courses. We also need to open up conversation with those faculty members who teach these courses and discuss more fully the needs of preservice teachers of the "90's."

Southwest Missouri State University Springfield, MO

Contact person: Lynda Morton
Department of Mathematics
27M Cheek Hall
Southwest Missouri State University
Springfield, MO 65804-0094
Phone: (417) 836-4152
e-mail: lsm953f@vma.smsu.edu

Demographic Information

Type of school: Comprehensive

Size of undergraduate student population: 15,577

Average number of graduates over the past three years:
Secondary mathematics: 15-20
Elementary (general): 200
Elementary (math specialist): 15-20
Middle Level/Junior High: 25

Course Information

A. Elementary Program
Required number of hours in mathematics: 9
Additional number of hours required for elementary specialty in mathematics: 12
Required number of hours in mathematics methods: 3

B. Middle Level/Junior High Program
Required number of hours in mathematics: 21
Required number of hours in mathematics methods: 3

C. Secondary Program
Required number of hours in mathematics: 38
Required number of hours in mathematics methods: 3

Mathematics courses in addition to those shown in table.

Required	Electives
Algebraic Structures	Foundations of Geometry
Advanced Calculus I	Non-Euclidean Geometry
Senior Seminar	Statistical Theory

Institutional Mission

Southwest Missouri State University is a comprehensive university located in the center of a unique metropolitan region while serving a state-wide clientele. The University system comprises three campuses: a selective admissions campus at Springfield, a research campus at Mountain Grove, and an open admissions campus at West Plains. The University has a three-fold mission to provide quality instruction, to further research and scholarly inquiry, and to provide service. The institution is committed to support these activities as integrated functions.

Institutional Concerns Addressed

(1) Develop and implement new mathematics courses to prepare middle school teachers for changing certification requirements in Missouri.

(2) Increase elementary mathematics content coursework from 6 to 9 hours.

The State of Missouri revised its teacher certification requirements and initiated new middle school certification, to begin fall 1997. As a result, institutions throughout the state, including Southwest Missouri State University, scrambled to redesign their teacher education programs. To promote collaboration among state educators in establishing statewide standards for mathematics preparation of teachers, the Missouri Mathematics Association for the Advancement of Teacher Training $(MAT)^2$ and Missouri's Department of Elementary and Secondary Education (DESE) offered two conferences. Team members attending the "Leading the Way to Systemic Change" conference participated in both program change discussions at this University and the two collaborative conferences offered by $(MAT)^2$ and DESE. As a result new mathematics requirements for both middle and elementary education programs were set and new courses designed. New elementary education requirements included three mathematics courses (Contemporary Mathematics, Foundations of Mathematics for Teachers, and Foundations of Geometry for Teachers) instead of two, for a total of 9 credit hours. A new probability and statistics course for all middle school preparatory teachers (Foundations for Probability and Statistics for Teachers) was developed and scheduled to begin fall 1995. Geometry and calculus course development appropriate for middle school teacher preparation was also begun. The new courses were designed to be activity- and technology-based, so proposals were submitted to funding agencies in an attempt to secure a computer classroom in which to teach. The team plans to monitor results of changes and continue the development of new mathematics coursework appropriate to the training of future teachers. Barriers which continue to slow progress include: time to develop courses, institutional governance hurdles, administrative commitment to programs, and competing demands for degree hours of education students.

(3) Establish a monthly mathematics education seminar to promote collaborations among teacher educators, mathematics educators, mathematicians and students.

Team members started the monthly Teaching and Learning Mathematics Seminars at this institution beginning last August. Through an organizational meeting, seminar format and topics of interest were determined. The seminars included individual presentations and panel discussions of current issues and research in the area of mathematics education, including teacher preparation. Sample titles of these seminars included "A Call For Change in My Mathematics Classroom?," "Systemic Change to Authentic Mathematics Assessment," "Alternative Assessment, Rubrics, Portfolios and Other Things That Go Bump in the Night," and "MAP 2000: Missouri Assessment Project." These seminars were well received by mathematics educators at the University and local high schools, but attracted only a few mathematicians and students at this University. The team members are currently reevaluating the design and content of these seminars to attract more members from the Department of Mathematics.

University of Missouri-Columbia Columbia, MO

Contact Person: Robert E. Reys
212 Townsend Hall
University of Missouri
Columbia, MO 65211
Phone: (314) 882-3740
e-mail: cirr@showme.missouri.edu

Demographics Information

Type of school: Doctoral

Size of undergraduate student population:

Average number of graduates over the past three years:
Secondary mathematics: 15-20
Elementary (general): 100-120
Elementary (math specialist): 20-25
Middle Level/Junior High: New program

Course Information

A. Elementary Program
Required number of hours in mathematics: 15
Additional number of hours required for elementary specialty in mathematics: 6
Required number of hours in mathematics methods: 3

B. Middle Level/Junior High Program
Required number of hours in mathematics: 24
Required number of hours in mathematics methods: 6

C. Secondary Program
Required number of hours in mathematics: 40
Required number of hours in mathematics methods: 9

Mathematics courses in addition to those shown in table.

Required	Electives
Matrix Theory	Advanced Calculus

Institutional Focus

One of our goals is to provide a quality program in mathematics and mathematics education that leads to state certification for middle school and secondary mathematics teachers. A second goal is to have a quality program for all elementary education majors which, among other things, gives them the understanding and tools in mathematics and mathematics education that all elementary teachers need.

Institutional Approach

Concern
Providing a quality program in mathematics and mathematics education.

Proposed Action
Collaboration between the faculty in mathematics education and the Department of Mathematics to modify existing courses and develop new courses which are required for teacher certification.

Action Taken
The faculty conduct informal follow-up of recent graduates, study national documents, such as *Professional Standards for Teaching Mathematics*, maintain contact with the Missouri State Department regarding teacher certification requirements and examine our current program from these different perspectives. Changes in our program are made to insure that a high quality program is maintained.

During the last few years, these collaborations have led to major revisions of the two required mathematics courses for elementary teachers and the development of several new courses targeted toward specific populations, such as Calculus for Middle Grade Teachers and Geometry for Middle Grade Teachers. The development of specific audience courses is being done recognizing that if course enrollments are not sufficient to "make" a class that these courses will not be offered on a regular basis. Plans are also being made to provide closer links between school based programs and university preparatory courses related to the mathematics education component.

In addition to developing current course offerings, faculty in the Department of Mathematics and the College of Education are working together on several different mathematics education projects funded by different agencies, such as the Coordinating Board of Higher Education, Missouri Department of Elementary and Secondary Education and the National Science Foundation.

Next Steps
Continue this effort.

UNIVERSITY OF NEBRASKA-LINCOLN
Lincoln, NE

Contact Person: Mel Thornton
Department of Mathematics and Statistics
University of Nebraska-Lincoln
Lincoln, NE 68588-0323
Phone: (402) 472-7234
e-mail: mthornto@unlinfo.unl.edu

Demographics Information

Type of school: Doctoral

Size of undergraduate student population: 18,700

Average number of graduates over the past three years:
Secondary mathematics: 40
Elementary (general): 125
Elementary (math specialist): 10
Middle Level/Junior High: 5

Course Information

A. Elementary Program
Required number of hours in mathematics: 9
Additional number of hours required for elementary specialty in mathematics: 6
Required number of hours in mathematics methods: 3
Additional number of hours methods required for elementary specialty in mathematics: 6

B. Middle Level/Junior High Program
Required number of hours in mathematics: 20
Required number of hours in mathematics methods: 3

C. Secondary Program
Required number of hours in mathematics: 32
Required number of hours in mathematics methods: 9

Mathematics courses in addition to those shown in table.

Required	Electives

Institutional Focus

The University of Nebraska-Lincoln is a land-grant institution, the largest post-secondary institution in the state and the flagship campus of the University system. As the only doctoral granting institution in the state, it has a full graduate program. Ph.D., MA, and MAT degrees are offered by the Department of Mathematics and Statistics. Ph.D. and Ed.D. degrees are offered through the Teachers College. In Lincoln the total enrollment (undergraduate, graduate and professional) is over 24,000. UNL certifies more teachers than any other state institution.

Institutional Approach

Main Concern

To support and encourage quality K–12 mathematics education in the state of Nebraska.

Approach

Support and encouragement of math education needs to be done through direct work with in-service teachers, work with colleagues in Education preparing pre-service teachers, and work on general policy issues. Current teachers deserve quality professional enhancement opportunities in both content and teaching methodology. Communication, coordination, and collaboration needs to be improved between Mathematics Education and the Department of Mathematics and Statistics. Requirements need to be set and opportunities given to encourage all students to gain a solid mathematical education.

Actions Taken

The Department of Mathematics and Statistics has a history of involvement with mathematics teacher enhancement programs. The NSF funded Nebraska Math Scholars Program and the Western Math Scholars Program provided summer academic institute experiences in mathematics for over 200 middle and secondary mathematics teachers. It also prepared teachers for leadership in math education in Nebraska and four adjoining states. With the help of these Math Scholars, the department formed the Nebraska Mathematics Coalition which was successful in obtaining NSF support for the Nebraska Math and Science Initiative (NMSI.) The original three PIs of this Statewide Systemic Initiative were from the department.

NMSI in turn has held eight summer institutes for lead teachers of both mathematics and science. These lead teachers are now presenting PEERS Academy workshops for other teachers in the state. This year Excellence in Education funds were obtained which will allow additional PEERS workshops to be given in the next two years. This will total over 120 workshops providing teaching materials and experiences for over 2,400 K-12 teachers. NMSI has also provided innovative mathematical videotapes and curricular materials (Math Vantage) for the year before Algebra 1 and a televised senior

level mathematics course for students planning to attend college. The Math Vantage materials are nationally available and are used extensively, especially in Nebraska. This year we have also held two institutes in Elementary Quantitative Literacy (EQL) for intermediate teachers and a geometry course for teachers was taught in a local elementary school. The EQL institute involved team teaching and collaboration among a mathematics education professor, a biometrics professor, and a team of elementary teacher leaders from the PEERS Academies. The gometry course was taught by a team made up of a mathematics education professor, the technology consultant for Lincoln Public Schools, and the director of the NMSI PEERS Academies for K-6 teachers.

In the past year there has been considerable change in the Mathematics Education faculty: two of the three members have retired or shifted from active participation in the undergraduate program. The third faculty person moved from elementary mathematics education into secondary mathematics education. Two new faculty were hired in elementary mathematics and middle-level mathematics education. Several Mathematics and Statistics faculty were involved in the selection of these two new mathematics education faculty. In addition a content mathematician was on the academic program review panel that reviewed the department of Curriculum and Instruction which houses Mathematics Education. That same professor served on the selection committee for the new chair for Curriculum and Instruction and on the committee to select the mathematics consultant for the local school system.

Another example of collaboration between the two departments is the fact that a professor from each department worked together to plan the original Leading the Way to Systemic Change workshop and the follow-up meeting. Professors from both departments were successful in funding a Teachers In Partnership project which is working on improving content courses for teacher certification. Other collaborative efforts include an on-going weekly seminar in the Science, Math and Technology Education center on teacher preparation.

Talks are underway in the Mathematics and Statistics department and with Curriculum and Instruction to plan a doctoral program option of writing a thesis relating to collegiate mathematics instruction. Graduate students in this option would take a minor in Education consisting of courses related to research in educational issues. A small group will continue to work on developing this program in the coming year. Professors from both departments are also collaborating in developing guidelines for a concentration in mathematics for elementary education majors and updating requirements for middle level and high school education majors.

This past year, as in previous years, the department has sponsored two activities which encourage secondary mathematics students. Math Day at UNL brought over 1000 students from over 90 schools to campus for a day of friendly mathematics competition and experience. A total of $34,000 of scholarships were awarded after the competition. JUMP (Junior Mathematics Prognosis)

is a program where tests are given to juniors in high schools to assess their readiness for college level mathematics. Individual follow-up letters are sent to the participants to inform them about the courses they are prepared to enter and to encourage them to take a mathematics course as a senior.

The chairman of the department has been successful in working to raise the mathematics entrance requirements for the University. And this year, through the efforts of many faculty, a new general education program is in place that requires at least one mathematics course for all students. Faculty have also been active in forming the state guidelines for teacher preparation in mathematics education.

A mathematics education professor is a site director for an NSF grant for implementing the NCTM's discrete mathematics standard. This project focuses on discrete mathematics content and methods of teaching. The participants are 25 high school and middle level teachers and 5 professors from mathematics or mathematics education for each of two summers. Participants are required to implement knowledge gained during the summer program in their own classes and to conduct inservice activities in their respective school districts.

Next Steps

More PEERS Academy workshops will be given over the next two years. We will continue to provide resources and guidance for the content of these workshops. We will work with the new mathematics education faculty to insure the content in the required mathematics courses for certification meet the needs of these teachers. We will also work with these colleagues to coordinate the use of technology in the content and methods courses. The Teachers In Partnership program will be supported to encourage dialogue among mathematics content and mathematics education colleagues in all the institutions across the state.

UNIVERSITY OF NEBRASKA AT OMAHA
Omaha, NE

Contact Persons: Elliott Ostler and Neal Grandgenett
Department of Teacher Education
University of Nebraska at Omaha
Omaha, Nebraska 68182
Phone: (402) 554-3486 or (402) 554-2690
e-mail: ostler@cwis.unomaha.edu
grandgen@cwis.unomaha.edu

Demographics Information

Type of school: Comprehensive

Size of undergraduate student population:

Average number of graduates over the past three years:
Secondary mathematics: 18
Elementary (general): 150
Elementary (math specialist): 5
Middle Level/Junior High: N/A

Course Information

A. Elementary Program
Required number of hours in mathematics: 3 (Soon to be 6)
Additional number of hours required for elementary specialty in mathematics: 15
Required number of hours in mathematics methods: 3

B. Middle Level/Junior High Program
Required number of hours in mathematics: N/A
Required number of hours in mathematics methods: N/A

C. Secondary Program
Required number of hours in mathematics: 45
Required number of hours in mathematics methods: 3

Mathematics courses in addition to those shown in table

Required	Electives
Applied Engineering Problems and Statistics	
Statistical Methods	

The University of Nebraska at Omaha

A comprehensive, public university, the University of Nebraska at Omaha (UNO) is located in the heart of Nebraska's largest city, Omaha. The role and mission of UNO reflect a distinctively metropolitan emphasis. Accordingly, many of the academic majors, research activities and public service programs respond to its urban/suburban environment. UNO also has statewide responsibility for providing programs and services in criminal justice, gerontology, public administration, urban studies and social work. It includes more than 400 faculty members, and offers 133 baccalaureate degree and programs. UNO also offers 64 graduate and advanced degree programs, including six doctoral programs.

The students of the University of Nebraska at Omaha are a diverse group, with different ethnic backgrounds well represented on campus. Although the majority of students come from within a 100 mile radius of Omaha, one-third of the student population represents each state in the nation and 60 countries. The mean age of 27 years of UNO students is becoming the national model, with an even representation of students fresh out of high school and of older adults who are beginning or returning to college.

Teacher Preparation in Mathematics

The Math Education program exists within the Department of Teacher Education in the College of Education. Although formal program responsibility exists within the College of Education, mathematics education faculty within this college rely regularly on strong cooperation and communication with their colleagues in the Department of Mathematics, the Department of Computer Sciences, and local elementary and secondary classroom teachers. The mathematics education program offers three main options: two secondary education options and one elementary education option.

Students at the secondary level may receive state certification in Mathematics as a Teaching Field, or certification in Mathematics as one of two Teaching Subjects. The "Teaching Fields" option allows the student to concentrate more heavily in mathematics and computer science courses, whereas the "Teaching Subject" option allows the student to be certified in two distinct teaching areas and attain more of a cross-disciplinary background.

Students at the elementary level have the opportunity to pursue a Professional Specialization in Mathematics Education that permits more extensive preparation in mathematics education than attained through courses in the regular elementary education program. This program is not a state certified program but does provide the opportunity for interested students to specialize more formally in the teaching of mathematics at the elementary level.

The teacher preparation program in secondary mathematics graduates approximately 15 graduates per year, and approximately 10 mathematics specialists at the elementary level each year.

University of Rio Grande/Rio Grande Community College Rio Grande, OH

Contact person: Mary Jane Wolfe
College of Mathematics, Natural Sciences, and Computer Science
University of Rio Grande
Rio Grande, OH 45674
Phone: (614) 245-7243
e-mail: mwolfe@discovery.oar.net

Demographics Information

Type of school: 4 year

Size of undergraduate student population: 1925

Average number of graduates over the past three years:
Secondary mathematics: 4
Elementary (general): 24
Elementary (math specialist): 6
Middle Level/Junior High: N/A

Course Information

A. Elementary Program (Quarter Hours)
Required number of hours in mathematics: 14
Additional number of hours required for elementary specialty in mathematics: 31
Required number of hours in mathematics methods: 5

B. Middle Level/Junior High Program (Quarter Hours)
Required number of hours in mathematics: N/A
Required number of hours in mathematics methods: N/A

C. Secondary Program (Quarter Hours)
Required number of hours in mathematics: 52
Required number of hours in mathematics methods: 0*
*Students take 5 credits general secondary methods course.

Mathematics courses in addition to those shown in table.

Required	Electives

Institutional Mission

The University of Rio Grande/Rio Grande Community College provides programs in the liberal arts, sciences, business, teacher education, fine and performing arts, nursing, and technologies. URG grants Associate's, Bachelor's and Master's degrees; Rio Grande Community College offers a variety of credit and non-credit courses, seminars, workshops and events as part of lifelong learning and enrichment. Historically, URG's primary focus has been students from the Appalachian region. URG is now more cosmopolitan with enrollments from states outside the region and foreign countries. The University emphasizes learning that prepares students for the many occupations and professions necessary to live and work in a global community.

Concerns/Actions Taken

(1) We believe prospective teachers must experience the learning of mathematics in ways we would expect them to teach.

(2) We propose to approach the challenge through several paths: frank and frequent communication among mathematics faculty, faculty in the College of Education who teach math methods courses, and administrators; having these same individuals team-teach courses; and revising curricula.

(3) We have revised the math curriculum in several ways that positively influence the preparation of pre-service teachers in mathematics. For example, the prerequisites for the mathematics content courses for prospective elementary teachers were raised to include Introductory Algebra. Not only does this free up valuable instructional time, but it effectively shifts the courses from the freshman year to the sophomore year.

We have revised the syllabus and format of instruction in the College's entry level developmental mathematics course. This course was taught by a team of teachers: the mathematics methods professor, a mathematics professor, and a dean. Students were given the chance to use manipulatives, write about their experiences as learners, work in cooperative groups, and understand the mathematics behind the fundamental arithmetic operations. Evaluation was accomplished through the use of standardized instruments, and through student self-evaluation. In addition, one of us has begun teaching in these ways in other mathematics courses, those taken by mathematics majors, many of whom are also prospective secondary teachers.

(4) Our immediate plans are to extend the changes outlined above into the second developmental mathematics course, introductory algebra. Because so many of our students test into developmental courses, this is a particularly fertile ground for them to begin to experience the utility and the power of new methods of teaching and learning mathematics.

University of Wisconsin-Oshkosh Oshkosh, WI

Contact person: John Koker
Mathematics Department
University of Wisconsin-Oshkosh
Oshkosh, WI 54901-8631
Phone: (414) 424-1333
e-mail: koker@vaxa.cis.uwosh.edu

Demographics Information

Type of school: 4 year comprehensive

Size of undergraduate student population: 10,000

Average number of graduates over the past three years:
Secondary mathematics: 8
Elementary (general): 145
Elementary (math specialist): 18
Middle Level/Junior High: N/A

Course Information

A. Elementary Program
Required number of hours in mathematics: 9
Additional number of hours required for elementary specialty in mathematics: 15
Required number of hours in mathematics methods: 3

B. Middle Level/Junior High Program
Required number of hours in mathematics: 24
Required number of hours in mathematics methods: 3

C. Secondary Program
Required number of hours in mathematics: 40
Required number of hours in mathematics methods: 3

Mathematics courses in addition to those shown in table.

Required	Electives
Computing Mathematics	
Problem Solving Seminar	

Institutional Mission/Focus Statement

The mathematics faculty believes a teacher of mathematics must have a strong knowledge of mathematics and the ability to communicate the subject effectively. Our program reflects that philosophy.

Mathematics is a critical facet of modern society. Thus, the transmission of mathematics to young people is particularly important to both the personal development of those individuals and for the progress of this nation. Our goal is to meet and exceed the needs of preservice and inservice teachers. Using the standards of professional societies as our guide, we aim to continue a strong program which is sensitive to the changing needs of the modern professional teacher.

Institutional Approach

I. a. We would like both inservice and preservice teachers to understand and value what is meant by teaching mathematics via problem solving.
   b. Inservice teachers - We have completed our fourth year of the workshop "Creating a Problem Solving Focus in the Middle Grades" funded in part by Eisenhower grants. Preservice Teachers - All preservice elementary teachers take three 3-credit mathematics classes which are presented with an activity/problem solving focus.
   c. We must continue to develop appropriate materials to meet the ideas outlined in (b) above. Evaluation is based on belief structures of inservice teachers who have been through our program.
   d. To continue our problem solving workshop and make sure our classes continue to model effective mathematics instruction.

II. a. We need to introduce the meaningful use of technology in the mathematics courses for preservice teachers.
   b. We must design useful ways to implement existing software into courses and obtain funding for the purchase of software.
   c. We have written one grant proposal which was unsuccessful.
   d. The next steps are to obtain the needed funds to acquire the necessary software.

III. a. We must increase cooperation between the Mathematics Department and the College of Education so that our mathematics and method courses are coordinated and perhaps even integrated.
   b. We have identified existing problems with coordination and are working to fix them.
   c. Good discussions have taken place between the two groups. We have been involved in each other's hiring process.
   d. To work together and modify our program so that it is one which truly benefits the preservice and inservice teacher.

Appendix B

Mathematical Preparation of Elementary School Teachers: Issues and Recommendations

"A child's mind is a fire to be ignited not a pot to be filled."

Experts agree: Excitement about learning mathematics is an important goal of school education. Dozens of reports have made hundreds of recommendations about how this goal might be achieved. Although many individuals and institutions have begun to implement these recommendations, their efforts have not yet had a significant nationwide impact on teacher education programs.

This brief paper suggests ways to transform these individual projects into a national movement. It has been prepared at the request of the Presidents and Executive Directors of five major mathematics professional societies[1] in order to articulate an agenda for these societies to help improve the mathematical preparation of elementary school teachers. It is intended:

- to synthesize current issues within the ever-changing context of educational reform;
- to marshal the energies of the professional societies on an agenda of action;
- to reach professional leaders who are ready to hear and act on the message.

Elementary school is important to children both for their cognitive development and as a foundation for further education. For children with weak academic support at home, the primary responsibility for providing this foundation rests on elementary classroom teachers. Society now expects that schools will successfully prepare all students to meet national standards in all subjects.

Many observers fear that the forthcoming standards in different school subjects will, when taken as a whole, be overly ambitious for students, surpass what teachers know, and exceed what parents believe to be essential. Although these standards often exhibit the ambitions of disciplines vying for center stage in the education reform movement, they tend to be consistent in their emphasis on active learning and in their constructivist perspectives. The pressure of multiple standards ensures that teacher preparation programs are and will remain in constant flux.

Preparation for elementary school teaching is a life-long activity, encompassing teachers' experiences as K-12 students, as undergraduates, and as profes-

[1] The American Mathematical Association of Two-Year Colleges (AMATYC), the American Mathematical Society (AMS), the Mathematical Association of America (MAA), the National Council of Teachers of Mathematics (NCTM), and the Society for Industrial and Applied Mathematics (SIAM).

sionals who learn from experiences throughout their careers. The formal teacher preparation program—post-secondary but pre-service—occupies a relatively short but crucial part of this experience. The focus of this report, reflecting the missions of the professional societies to whom it is addressed, is on just one component of teacher preparation: the mathematical preparation of prospective elementary school teachers.

Prospective elementary school teachers encounter mathematics in several different contexts: *content courses,* usually offered by departments of mathematics; *methods courses,* usually offered by faculty with appointments in education departments; and *experiences in school classrooms,* supervised by practicing elementary school teachers. Each encounter should offer solid mathematics and model sound pedagogy, and all should work together to provide a consistent view of mathematics. The special focus of this paper is on one leg in this triad—what goes on under the jurisdiction and responsibility of departments of mathematics whose members form the constituencies of the mathematics professional societies. However, in order to ensure the success of teacher preparation programs, it is necessary that firm linkages be established and maintained between all three components of the prospective teacher's mathematical preparation.

A coordinated effort, led by the professional mathematics societies and focused on promoting successful teacher preparation programs, can break what some critics have described as the "cycle of failure" in mathematics teaching. It can also encourage more college and university faculty to make teacher preparation a higher priority in their own professional lives. Thus it is especially timely for professional societies to undertake a special initiative to bring about much-needed improvement in the mathematical preparation of elementary school teachers.

The following recommendations build on a history of public statements and address unresolved issues and emerging ideas in a context that is within the authority and mission of the mathematical professional societies:

Make a Commitment
The mathematics professional societies should develop and make public a consensus statement regarding the critical importance of the mathematical preparation of elementary school teachers.

Fulfill the Commitment
The mathematics professional societies should develop a coordinated program of activities and publications to support their members in providing outstanding mathematical education to prospective elementary school teachers.

Extend the Commitment
The mathematics professional societies should work both at the national level and with their state and local affiliates to develop strategies for engaging and influencing educational policy.

Making A Commitment

Recommendation

The mathematics professional societies should develop and make public a consensus statement regarding the critical importance of the mathematical preparation of elementary school teachers.

A well-publicized consensus statement by the professional societies would provide a visible public commitment that can create a platform for further action by the entire mathematical community. A basis for that consensus statement can be found in recommendations contained in reports on the mathematical preparation of elementary school teachers. These recommendations, summarized below, suggest considerable agreement on the requisite characteristics of strong programs:

1. *Mathematics departments should take seriously the challenges and obligations of courses intended for prospective elementary school teachers.* Too often, "mathematics for elementary teachers" is a neglected component of a mathematics program, scorned by senior faculty and assigned to teachers with least seniority or without appropriate expertise. To restore vitality to mathematics education, these courses should be viewed instead as cornerstones of a department's program—courses with the capability of doing the greatest long-term good.

2. *Prospective elementary school teachers need to learn a broad range of elementary mathematics from an advanced perspective.* Elementary school teachers need to know (and to teach) much more than arithmetic. In order to help their students gradually develop abilities in abstract thinking, K-6 teachers themselves need to be comfortable with abstraction, generalization, and "symbol-sense." At the same time, in order to provide their students with substantive examples of the mathematics used in life and work, prospective teachers also need opportunities to apply elementary mathematics to problem-solving in realistic situations.

3. *Mathematics courses for prospective elementary school teachers should do more than cover a list of topics; they should help future teachers make sense of mathematics.* Elementary school teachers need a deep and robust understanding of the nature of mathematical thinking. Prospective teachers especially need to reflect on their experiences as students—what they have learned about the nature of mathematics and about the process of learning. They must come to understand that mathematics is about ideas, not just procedures, and that learning requires extensive engagement with those ideas. Then they must learn how to listen for and interpret students' mathematical ideas.

4. *Mathematics departments should provide prospective teachers with extensive opportunities to reflect on the important connections among content, pedagogy, and learning.* In addition to teaching mathematics and modeling appropriate pedagogy, the mathematical component of the

undergraduate program for prospective elementary school teachers should provide opportunities for students to reflect on their personal experiences in learning mathematics and to place those experiences in a broad professional context. Faculty in mathematics and mathematics education should work collaboratively to achieve these results.

5. *All college and university mathematics teaching should model the pedagogy that will be expected of future teachers.* Prospective teachers need extensive opportunities to construct for themselves the mathematics they will be teaching. "Enriched" courses that merely inject technology and hands-on activities into traditional courses consistently fail to penetrate prospective teachers' fundamental image of mathematics as a collection of answer-getting rituals. It is important that these courses connect students' hands-on experiences with the mathematics those experiences represent. All courses for prospective teachers should be designed to organize students' mathematical experiences in ways that help develop the habits of mind of those who use mathematics in their life and work.

6. *College courses for prospective teachers should illustrate the way mathematics is practiced.* Mathematics in practice uses technology, collaboration, communication, and exploration. Too often college and university faculty teach as they were taught when they were students rather than as their students will be expected to teach when they become teachers. The mathematical preparation of prospective teachers should enable them to implement an important goal of school mathematics—to prepare students to use mathematics at work and in their lives.

7. *Colleges and universities need to provide all prospective elementary school teachers with significant opportunities to learn how to teach children of diverse racial, ethnic, and linguistic backgrounds.* The reality of today's classrooms in the United States is that they are multicultural, multiracial, and multi-linguistic. Since effective mathematics learning arises from meaningful contexts, prospective teachers need opportunities to learn multiple contexts in which to make mathematics significant to their students. Therefore it is especially important that mathematics faculty participate fully in opportunities offered by their institutions to learn about diverse teaching and learning strategies.

8. *Courses for prospective elementary school teachers should include significant coverage of the contributions to mathematics of diverse cultural and ethnic groups.* Not all mathematics was discovered by any one culture or gender, but the dominance of one perspective in most presentations of mathematics tends to exclude women and people of different cultures from the community of mathematical scholars. Especially since schools in the United States are so multicultural, it is vitally important that prospective teachers become fully aware of the universal

character of mathematics and the influence of various cultures on its evolution.

9. *College and university mathematicians need to develop effective working relationships, based on mutual respect, with those who have a stake in school mathematics.* Effective programs to prepare elementary school teachers require collaboration among mathematics educators, mathematicians, education faculty, and school teachers. Such collaboration should extend also to non-educators—business and civic leaders, parents and taxpayers.

Fulfilling the Commitment

Recommendation

The mathematics professional societies should develop a coordinated program of activities and publications to support their members in providing outstanding mathematical education to prospective elementary school teachers.

Mathematics faculty in colleges and universities bear primary responsibility for the mathematical preparation of elementary school teachers, but they often work in isolation, lacking suitable infrastructure to strengthen their professional engagement with this undertaking. This is a need the professional societies are especially constituted to meet, both through cooperative and coordinated activities and through special initiatives addressed to their own members. Strategies could include:

- Activities at annual and regional meetings designed to promote a sense of community among those who are involved in the mathematical preparation of prospective elementary school teachers.
- Workshops, minicourses, and other opportunities to prepare mathematics faculty and graduate students to teach courses for prospective elementary school teachers.
- Dialogue sustained through newsletters, journals, and e-mail on issues in teaching and learning related to the mathematical preparation of elementary school teachers.
- Creation of an on-line "virtual journal" using "gopher" and "mosaic" to alert individuals to the presence and location of relevant articles published world-wide in current periodicals and to provide timely information about upcoming conferences.
- Stimulation of electronic networks among individuals across the country who are interested in sharing practices and consulting with one another.
- Dissemination of rich examples of promising practice in the mathematical preparation of elementary school teachers.
- Promotion of opportunities for college and university mathematicians to learn first-hand about the classrooms in which prospective teachers will work, about the new curricula that are available for K-6 settings, and about research concerning children's learning.
- Identification of resources that provide examples of interesting

mathematics and mathematical activities that can challenge pre-service teachers to think mathematically.
- Support for programs that provide prospective elementary school teachers with mathematics-rich experiences in non-academic settings.
- Discussion of diverse strategies to assess student learning including open-ended questions, group or individual projects, and student portfolios.
- Exploration of programs for specialist preparation in elementary mathematics and science teaching.
- Dissemination of case studies of departments of mathematics working with neighboring school districts to link mathematicians with elementary school children, teachers, and administrators.
- Providing examples of mathematicians and mathematics educators working collaboratively.

Many of these strategies are currently employed either in college and university programs or in activities of professional societies, but often their focus is on in-service teacher education. Responses to the special needs of pre-service education—the main focus of this recommendation—can build on experiences gained through these in-service programs by appropriate extension and adaptation. Such activities will take place in a variety of contexts ranging from higher education policy to the design of individual courses.

Higher Education Context

Whereas formerly most elementary school teachers were educated through a relatively predictable and standardized education major, today there are many conflicting and constantly changing models for teacher preparation programs:
- Traditional programs leading to a major in education with minimal course work in mathematics.
- "Holmes"-type programs in which the undergraduate education major is abolished in favor of traditional subject-matter majors.
- The "Project 30 Alliance" in which liberal arts courses are substituted for education courses in an attempt to enrich the traditional education major.
- "Alternative certification" in which anyone with a university degree can obtain a teaching certificate through a combination of supervised teaching and special examinations, often without any additional mathematics content or pedagogy courses.

In many states, the majority of students who become elementary school teachers begin their post secondary education in two-year colleges where they take some or all of their required mathematics credits. Even though they may not think of themselves as teacher-preparation institutions, these two-year colleges represent an entry point to careers in elementary education for many students, especially minority students.

Although standards for mathematics content for teacher preparation are explicated in *A Call for Change*, the diverse and ever-changing variety of teacher preparation programs may allow prospective teachers to avoid the breadth of mathematics recommended in that document. Moreover, as other disciplines argue effectively for the inclusion of courses in their areas, mathematics requirements may be diminished to accommodate crowded programs. It is important, therefore, that mathematicians play a critical role in developing and implementing sound educational programs for prospective elementary school teachers.

Departmental Context

Full recognition of the importance of elementary school teacher preparation will require explicit broadening of the mission of mathematics departments in most post-secondary institutions, and full engagement of the faculty in those departments. In institutions with programs to prepare elementary school teachers, mathematics departments must recognize their role in the mathematical preparation of these teachers and their responsibility to provide continuing resources (seminars, Internet access, consulting support, summer institutes) to support their graduates and other teachers in neighboring communities. In many cases, this may require enlarging the department's mission and securing additional resources. Mathematical preparation of teachers doesn't end with their college courses.

A recent report by the Joint Policy Board for Mathematics (JPBM) has launched a vigorous campaign to broaden the basis for recognizing and rewarding mathematics faculty. This effort includes recognition of the importance of program development, teaching, and scholarship associated with the mathematical preparation of teachers. Where these changes are implemented, faculty who teach courses for prospective elementary school teachers will more readily secure the time, opportunity, and resources needed to focus on this kind of work. Especially in times of limited budgets, departments can make a strong statement of support for these efforts by giving priority to the special resources needed by those who teach prospective teachers.

As mathematics departments wrestle with the challenges of improving teacher preparation, the professional societies can provide needed stimulation by providing information about programs that work. In addition to strengthening routine courses, certain evolving areas require special attention:

Learning from Research

Faculty teaching mathematics to prospective teachers need to know what research says about children's learning of mathematics. They also need to incorporate the results of that research into the courses they teach, which is not an easy matter. It is not enough to explain the results of current research literature on how children learn mathematics to prospective teachers or merely to ask them to read research reports. Prospective teachers need opportunities to experience for themselves the principles embodied in that research.

Mathematics in Practice

Teachers need real-world experiences of the practice of mathematics and science in order to portray accurately the nature of these disciplines. All too often, teachers enter their careers without ever having experienced any work situation other than education—first as students, then as teachers. To understand the ways mathematics is used, it is important for prospective teachers to have internships—like opportunities in real work sites. Departments can work with local employers to create internships for prospective teachers just as they now do for students who are interested in careers in business and industry.

Supporting Multicultural Education

Teacher preparation programs are beginning to address the crucial need to prepare teachers for multicultural, multiethnic and multilinguistic classrooms by developing courses in multicultural education. Yet most mathematics programs for prospective elementary school teachers have only tenuous links to these generic courses, largely for lack of appropriate historical and cultural materials suitable for elementary school mathematics instruction. Thus, prospective teachers have few opportunities to see mathematics as a multicultural activity, and to overcome the hidden racial and class biases of those who have not had a chance to live and work in multicultural environments. Professional societies can help mathematics departments by gathering and disseminating materials appropriate to this particular need.

Mathematics Specialist

Many observers have urged that the United States adopt a model of specialist teachers in elementary school, and many districts have been experimenting for some time with various roles for specialists. Magnet programs, building and district specialists, and paired teaching (e.g., language arts and science-mathematics) all fall within the general scope of such specialist programs. Yet there is no common understanding within the mathematics community about the appropriate preparation of mathematics (or mathematics-science) specialists for elementary school, nor has there been much work done on developing courses especially suitable to this goal. What do specialists need in way of preparation that generalists do not also need? Surely the answer is not just more courses suitable to high school or college teachers. To permit exploration of this idea, the community needs better information about experimental programs, as well as serious dialogue about how to approach elementary school mathematics from an advanced perspective.

Evaluating Programs

Assessing program effectiveness is crucial to achieving quality. Assessment is especially important and delicate in situations in which approaches to teacher preparation are exploratory or part of special curriculum development projects. Most mathematics faculty know very little about program evaluation or classroom-based research. Increased knowledge about these areas would better po-

sition mathematics faculty to respond to questions raised by the public about the status of progress toward the national goal of improving mathematics education. It would also enable mathematics faculty to take leadership roles within their own communities when issues arise about mathematics education reform.

Professional Context

The variety of current courses and the conflicting recommendations for change in teacher preparation programs can be resolved only through dialogue among elementary school teachers and administrators, mathematics educators, and college and university mathematicians. Increased dialogue will make all those involved think more deeply about the broad context of mathematics education, as well as about their own work.

However, many barriers to effective communication still divide these different constituencies. Much of the literature of mathematics education is written in a language that mathematicians find difficult to understand, and most articles about mathematics are written in ways that are not useful to teachers and mathematics educators. Faculty at two- and four-year colleges rarely talk with one another about matters of teacher preparation, even though many prospective teachers complete half their post-secondary education (and often all their mathematics credits) in two-year colleges. Effective programs for preparation of elementary school teachers also will require on-going substantive contacts between college faculty and elementary school teachers. Professional societies can help by using sessions at meetings and articles in journals to break down the barrier of jargon that impedes effective communication on issues involving mathematics education.

Mathematics faculty who teach courses for prospective elementary school teachers often have inadequate experience and understanding of how children learn mathematics. As often as not, they generalize unwarrantedly from experience with their own or their friends' children and thus fail to recognize the enormous diversity in how children construct mathematical knowledge. Yet each year scores of faculty and graduate students are asked to take on the assignment of preparing elementary school teachers—an assignment for which they have no preparation and for which there are virtually no programs to help provide necessary background.

The overwhelming need of faculty who teach courses for prospective elementary school teachers is for strategies to enable students to think mathematically. Yet none of the channels of information to which mathematics faculty normally turn provide adequate information. Often, only one person on each campus teaches the courses for elementary school teachers, so their only sources of collegial support are individuals in similar circumstances on other campuses. Resources that would be useful include surveys of relevant educational research, examples of challenging mathematical topics set in a context appropriate for elementary school, samples of curriculum materials, and information about teacher preparation programs that exemplify research-based rec-

ommendations. Professional societies can play a unique and valuable role in linking individuals on different campuses to create a nation-wide focus on this issue.

Course Context

Courses designed to prepare elementary school teachers typically seek to achieve one or more of the following broad objectives:

- *Competence:* In-depth introduction to the mathematics of a standards-based elementary school education, including arithmetic, geometry, probability, algebra, modeling, and data analysis.
- *Exploration:* Reflective experience in thinking mathematically and in constructing one's own mathematical knowledge. Emphasis is on the nature of mathematical inquiry, not on the content of mathematics.
- *Understanding:* Broad survey of the big ideas and unifying themes of mathematics so as to reveal the subject as a whole and thereby to appreciate the foundation being laid during elementary school.

Ideally, these goals should be integrated into all mathematics courses for prospective elementary school teachers because they are, fundamentally, the goals that all elementary school children should achieve.

Instructional strategies for these courses should address these three goals for mathematics, should model good pedagogy, and should employ assessment strategies related to the goals of the course. This last is especially important since prospective teachers must explicitly learn how to assess their students' mathematical knowledge in terms of competence, exploration, and understanding. One challenge for mathematics faculty teaching prospective teachers is to find ways to assess student learning, especially among students with non-traditional backgrounds or whose understanding of mathematics may not be revealed through traditional testing. Ordinary tests often fail to measure students' real skills; not even the experts quite know how to do it right.

Prospective teachers need to experience mathematics as their students will (or should), in an atmosphere that encourages and rewards exploration. Moreover, elementary school teachers often will be expected to integrate the teaching of mathematics with other subjects, especially science and social studies. Thus they need deep knowledge of the mathematics they will teach in elementary school, experience in making connections between different areas of mathematics, and broad understanding of the ways mathematics is used to solve real life problems. They should have frequent opportunities to explore significant mathematics—both abstract and applied—in contexts that are meaningful to them as adults. Their engagement with ideas of interest to adults will model the process that young children go through as they too pose and solve complex problems within their own spheres of interest.

Yet many mathematics courses that colleges and universities designate to meet the requirements for prospective elementary school teachers reflect a pattern of thoughtlessness if not disdain for the important mathematics that these teach-

ers really need to learn. The collegiate view of mathematical sophistication is to climb the algorithmic ladder that reaches from arithmetic to calculus. This is totally opposite to the NCTM Standards' view of elementary school mathematics as rich in horizontal linkages, mathematical modeling, active discovery, and opportunities for sense-making. All too often current courses for prospective elementary school teachers, driven by a text or syllabus to cover too many topics too rapidly, merely convince anxious students that they don't know mathematics, don't like mathematics, and really don't want to learn mathematics.

Several very different patterns prevail in providing the mathematical content knowledge for prospective elementary school teachers:

- Mathematics for Elementary School Teachers. A traditional 1-3 course sequence offered from standard textbooks at institutions with sufficient enrollment to maintain special courses in this area.
- Mathematics for Liberal Arts Students. In institutions with insufficient enrollments to warrant special courses, a variety of regular courses are allowed to count as the mathematics content credits for an elementary school teaching certificate.
- Variations on Algebra. Many institutions allow credits from the standard pre-collegiate algebra sequence to meet the mathematics content requirement for prospective elementary school teachers.

This variety represents uncertainty in the community about whether the mathematics that prospective teachers study should be a review of the mathematics they will teach or a strategy to help them become mathematical thinkers. MAA, NCTM, and NCATE consistently recommend that all prospective elementary school teachers take several courses in mathematics that prepare them to teach mathematics in a manner consistent with the NCTM Standards. Large institutions provide special courses to meet this goal; smaller institutions must often use general courses for dual purposes. Courses in mathematical modeling, problem solving, and finite mathematics are especially suitable for prospective elementary school teachers. The traditional collegiate mathematics curriculum, linearly ordered and based on gathering algorithmic skills, while possibly unsuitable for all students, is especially unsuitable for prospective elementary school teachers.

The role of technology is another area of uncertainty and controversy. This ambivalence, especially concerning calculators in elementary school, is often an impediment to integrating technology into mathematics courses taken by prospective teachers. Since the NCTM *Standards* advocate extensive use of calculators throughout all grade levels, prospective elementary school teachers need to be able to confidently integrate the use of calculators in their own classes in meaningful ways that enhance student learning. They must also be prepared to explain the value of calculators to interested and anxious parents. Therefore they must be proficient calculator users themselves, confident in their judgment of appropriate uses of calculators as aids in mathematical problem-solving.

Student Context

Important goals for the undergraduate mathematics program for prospective elementary school teachers are to help those students develop positive attitudes about mathematics as a discipline and to create excitement about learning mathematics. The program, likewise, should foster in future teachers beliefs about mathematics that will enable them to help children learn what is mathematically sophisticated, efficient, and elegant. However, in creating these programs, mathematics faculty have to be sensitive to the needs, interests and backgrounds of students entering teacher preparation programs.

Like many other students, prospective elementary school teachers often have weak mathematics backgrounds and high levels of math anxiety when they enter college. Unlike many other students, however, elementary school teachers will use mathematics throughout their careers: they will teach mathematics to future generations of children and will have a significant impact on their students' understanding and attitudes. So it is especially important that college mathematics courses for prospective elementary school teachers build on what students know, recognize the reality of anxiety-induced inhibitions, and enhance students' self-confidence as potential learners of mathematics. For some, especially those with particularly weak high school mathematics backgrounds, it may take longer to achieve the expectations of *A Call for Change*. Mathematics departments need to find flexible means of accommodating the anxieties and varied backgrounds of students while maintaining high program standards.

Extending the Commitment

Recommendation

The mathematics professional societies should work both at the national level and with their state and local affiliates to develop strategies for engaging and influencing educational policy.

Certification standards for elementary education are controlled by state policy, either directly from a central office or indirectly through mandates to local educational agencies or institutions. Mathematicians typically know little about these processes, even though they are responsible for implementing many features of the policies. Issues concerning specialist teachers, state frameworks for mathematics curricula, student testing and promotion policies, local business expectations, teacher recertification, and articulation with higher education frequently flow through state agencies with whom university mathematicians have essentially no significant contact. Mathematics departments need to become informed about and engaged with those state-based organizations that influence mathematics education and in the various large scale reform programs (curriculum projects, regional laboratories, teacher enhancement efforts) and systemic initiatives (state, urban, rural) in their regions.

The public demand for accountability from the educational system requires methods of evaluation and measurement that will provide parents and employers with meaningful indicators of performance—both of students and of schools. Mathematicians, mathematics educators, and business leaders need to work together to set performance standards for both skills and understanding that meet legitimate expectations of industry and higher education. The dialogue thus engendered will help insure that students and parents are apprised of expectations, and that schools and teacher preparation programs will have a strong incentive for making the changes necessary to meet those expectations.

As part of this process, universities, particularly public universities, should become active partners in the political processes—both legislative and executive—through which teacher preparation and school education is regulated and assessed. So too should business and industry. Within the broad general context of educational policy, mathematicians in universities and in industry bear a particular responsibility to monitor and influence those policies that bear on mathematics education. Mathematics needs to have a voice in state and local policies in which the perspective of the schools' clients—industry and higher education—are strong and clear.

Some structures to achieve this do currently exist, although their strength and level of activity are highly variable. These include the NSF-supported state, urban, and rural systemic initiatives, the state coalitions for mathematics and science education begun by the MSEB; NSF Collaboratives for Excellence in Teacher Preparation; Eisenhower Partnerships; sections of MAA, and affiliates of AMATYC and of NCTM. With their natural reach into all states through publications and meetings, the professional societies could do much to encourage and coordinate their members' efforts to strengthen the voice of mathematics in local educational policy. They could, for example,

- Collect, cross-reference, and disseminate information about the range of practice in elementary teacher preparation from state to state;
- Examine the needs and varied responses of industry for a better educated local work force, including examples of where business and education have formed effective alliances to provide needed improvements;
- Provide examples of effective public action in support of sound policies regarding teacher preparation;
- Gather and publicize information about resources for teacher certification initiatives and the work of organizations such as NCATE and NBPTS.

Conclusion

Current thinking about the mathematical preparation of elementary school teachers reveals many possible areas for improvement and suggests impor-

tant activities that might be put on the agendas of the mathematics professional societies. Among the many challenges the profession faces, the mathematical preparation of elementary school teachers is one of the most important and most urgent. The professional societies can play a special role in providing national leadership to address this challenge. The impact of their efforts will increase to the extent that they can work together to create and implement an efficient agenda for action.

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Task Force Members

Deborah Ball, Michigan State University, East Lansing, MI
Patricia Campbell, University of Maryland, College Park, MD
Peter Costro, Eastman Kodak Company, Rochester, NY
Jacqueline Goodloe, Burrville Elementary School, Washington, DC
Carole LaCampagne, U.S. Department of Education, Washington, DC
James Leitzel, University of Nebraska, Lincoln, NE
Mercedes McGowan, William Rainey Harper College, Palatine, IL
Barbara Scott Nelson, Education Development Center, Newton, MA
Judith Roitman, University of Kansas, Lawrence, KS
Sheila Sconiers, University of Chicago, Chicago, IL
Cathy Seeley, University of Texas, Austin, TX
Tina Straley, National Science Foundation, Arlington, VA
Paul Trafton, University of Northern Iowa, Cedar Falls, IA

Appendix C

Guidelines For The Academic Preparation Of Mathematics Faculty At Two-Year Colleges

Approved by the AMATYC Delegate Assembly on 7 November 1992 in Indianapolis, Indiana

AMATYC Education Committee

Qualifications Subcommittee of the AMATYC Education Committee
Gregory D. Foley, Sam Houston State University, Chair, 1986–1992
Pansy Brunson, Community College of Western Kentucky University, 1987–1992
Robert L. Carson, Lower Columbia College, 1986–1987, 1990–1992
Sharon Douglas, Cochise College, 1990–1991
David Ellenbogen, St. Michael's College, 1986–1988
Michael E. Greenwood, Clark College, 1986–1992
Lou Hoelzle, Bucks County Community College, 1987–1988
Sue Parsons, Cerritos College, 1990–1992

Preface

Work on *Guidelines for the Academic Preparation of Mathematics Faculty at Two-year Colleges* began in 1986, when the Qualifications Subcommittee of the Education Committee of the American Mathematical Association of two-year Colleges (AMATYC) was formed. Extensive research—as well as consultation with other organizations, AMATYC committees, and mathematics faculty-led to this document. Developing and producing such a document and then obtaining all the necessary approvals to make it official was a long and arduous task. AMATYC is deeply indebted to Gregory D. Foley, Qualifications Subcommittee Chairperson (1986-1992), as well as the members of his subcommittee.

The report now presents, as much as is possible, à shared vision for the academic preparation of two-year college mathematics faculty. As its name implies, the report is intended to guide rather than control. It outlines one set of guidelines for all two-year college mathematics faculty. The most important recommendation of the report, however, is that "hiring committees for mathematics positions at two-year colleges should consist primarily of full-time two-year college mathematics faculty." They are the most qualified and have the best professional judgment to make appropriate hiring decisions, based upon any local constraints that may exist.

Karen Sharp AMATYC President (1991-93)

Statement of Purpose

This document is addressed to two-year college professionals involved in the staffing and evaluation of mathematics programs for their colleges, and to universities that have, or will develop, programs to prepare individuals to teach mathematics in two-year colleges. It is not intended to replace any regional, state, or local requirements or recommendations that may apply to hiring instructors, assigning them to classes, or evaluating their performance or qualifications. Rather, our goal is to provide guidelines that reflect the collective wisdom and expertise of mathematics educators throughout the United States and Canada regarding appropriate preparation for two-year college faculty involved in the teaching of mathematics, whether on a full- or part-time basis.

We strongly recommend that only properly qualified personnel be permitted to teach mathematics. Ill-prepared instructors can do much harm to students' knowledge of and beliefs about mathematics. Many two-year college students suffer from mathematics anxiety; this should not be reinforced or exacerbated through inappropriate mathematics instruction. Individuals trained in other disciplines should not be permitted to teach mathematics unless they have received sufficient mathematical training as well. Moreover, individuals hired to teach mathematics at one level should not be permitted to teach at another level unless they possess appropriate credentials.

We are guarding the gates of our profession. This is our responsibility as the leading professional mathematics organization that solely represents two-year colleges. Staffing practices and procedures vary greatly from college to college and from region to region. We wish to ensure the integrity of our profession and the quality of mathematics instruction at all two-year colleges.

Motivating Factors

Disturbing Trends

Reports such as *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* (National Research Council, 1989) document deep-rooted problems concerning mathematics education in the United States. Among these problems is the need to teach meaningful mathematics to individuals from all social, economic, ethnic, and racial backgrounds. This is imperative if our nation is to maintain a leadership role in the world of the future. The mathematics community should especially strive to increase participation of groups that are underrepresented in mathematics.

Two-year colleges can play a major role in turning our country around in this regard. A study conducted during the 1985-1986 academic year revealed that, among two-year college students, "one-fourth are minority students, and more than one-half are women" (Albers, Anderson, & Loftsgaarden, 1987, p. 112). Steen et al. (1990) reported that, "One-third of the first and second year college students in the United States are enrolled in two-year colleges, including over two-thirds of Afro-American, Hispanic, and Native American students" (p. 13). Two-year colleges are critical to the national effort to recruit and re-

tain minority students and women as majors in mathematics and mathematics dependent fields. Two-year college mathematics teachers must be prepared to help and encourage students from these underrepresented groups.

Many two-year college mathematics instructors are nearing retirement age (Albers, Anderson, & Loftsgaarden, 1987). We must work hard at recruiting and preparing the next generation of two-year college faculty, and enable them to thrive as college mathematics teachers in our rapidly changing world.

Curriculum Reform Movements

The forces of curricular change have reached a relative maximum. The *Curriculum and Evaluation Standards for School Mathematics* (Commission on Standards for School Mathematics, 1989) *and Calculus for a New Century* (Steen, 1988) call for major changes in the content and methods of school and college mathematics. These and other related calls for reform (e.g., National Research Council, 1989, 1991) are due in part to the implications of the pervasiveness of computer technology in our society and in part to the sagging mathematics achievement of students. It is appropriate that we now reexamine the preparation of two-year college mathematics faculty.

Guiding Principles

Two questions have guided the preparation of this report: What are the characteristics of an effective mathematics teacher? How can these characteristics be fostered and extended through academic preparation and continuing education?

The growing body of research related to effective mathematics teaching (Grouws, Cooney, & Jones, 1988) indicates that effective mathematics teachers use their time wisely and efficiently, both in and out of class; they present well organized lessons; and they know their subject. Effective instructors are reflective; they think about their teaching before they teach, while they teach, and after they teach. They are creative, resourceful, and dedicated. They use a variety of methods and respond to the needs of the particular class and students they are teaching. Effective mathematics teachers are skilled questioners who encourage and challenge their students. They are clear and careful communicators who recognize the importance of language in mathematics, and mathematics as language. They model the behaviors they wish their students to exhibit, especially problem solving, exploration, and investigation.

Effective mathematics instructors know a great deal of mathematics and understand the interconnections among its various branches as well as applications to other disciplines. They are continually developing their knowledge and understanding of mathematics, of teaching, and of how students learn. They are independent learners who can adapt and contribute to changes in collegiate mathematics curriculum and instruction.

Effective mathematics instructors are active professionals. They read journals, attend professional meetings, and engage in other professional activities. Impagliazzo et al. (1985) further elaborated on the activities and characteristics of professionally active mathematics instructors in *The Two-year College Teacher of Mathematics.* The present report outlines the academic preparation and continuing education necessary for a person to be an effective mathematics teacher at the two-year college level.

Organization of the Report

The remainder of this report is organized into four sections. The first concerns guidelines for the formal preparation of two-year college mathematics faculty. The second outlines important areas of mathematical and pedagogical content that should be included in such preparation. The third section discusses avenues other than formal education for continuing education. The final section briefly addresses the issues of part-time instructors and the desirability of diversity within a mathematics department. These sections are followed by a bibliography and an appendix that contains an outline for a course on college mathematics teaching. Such a course should be offered by universities that prepare two-year college mathematics instructors, and should be included in the academic preparation of these instructors.

Guidelines for Formal Preparation

Mathematics programs at two-year colleges reflect their diverse missions and particular needs. Mathematics instruction at a comprehensive community college may comprise adult basic education to prepare students for a high school equivalency examination; developmental and precollege vocational and technical courses designed to prepare students for college credit courses; courses for students in college-level vocational and technical programs; university transfer courses through vector calculus, differential equations, and linear algebra; and continuing education courses that do not carry college credit. Other colleges may focus only on a subset of these types of instruction. Many two-year technical colleges, for example, focus on precollege and college-level vocational and technical courses.

Because of this diversity, the standard for the mathematical preparation of two-year faculty must be sufficiently robust to guarantee faculty flexibility. This standard is divided into three parts: minimal preparation, standard preparation, and continuing formal education.

Definitions

All full- and part-time faculty should possess at least the qualifications listed under *minimal preparation*. All full-time faculty should begin their careers with at least the qualifications listed under standard preparation. All faculty should continue their education beyond this entry level. The continuing formal education section provides some suggestions. Continuing education of a less formal nature is not only valuable but essential. Avenues for informal

continuing education are discussed later in this report. Continuing formal education that requires full-time university enrollment is best undertaken after several years of teaching.

The terms *faculty* and *instructors* are used interchangeably to refer to persons who hold teaching positions. No particular level within a ranking system is implied by either of these terms.

Courses in physics, engineering, and other fields can contain significant mathematical sciences content. Although there is no simple, set formula for doing so, such courses should be taken into account by two-year college mathematics hiring committees when evaluating a candidate's transcripts. Similarly, such courses should be carefully considered by university personnel when making program admission decisions and advising students who hold or may seek two-year college mathematics teaching positions.

Minimal Preparation

All full- and part-time mathematics instructors at two-year colleges should possess at least a master's degree in mathematics or in a related field with at least 18 semester hours (27 quarter hours) in graduate-level mathematics. A master's degree in applied mathematics is an especially appropriate background for teaching technical mathematics. Course work in pedagogy is desirable.

Standard Preparation

All full-time mathematics instructors at two-year colleges should begin their careers with at least a master's degree in mathematics or in a related field with at least 30 semester hours (45 quarter hours) in graduate-level mathematics and have mathematics teaching experience at the secondary or collegiate level. The teaching experience may be fulfilled through a program of supervised teaching as a graduate student. Course work in pedagogy is desirable.

Continuing Formal Education

All mathematics instructors at two-year colleges should continue their education beyond the entry level. Appropriate continuing formal education would include graduate course work in mathematics and mathematics education beyond the level of the individual's previous study. Such advanced study may culminate in one of the following degrees: Doctor of Arts in mathematics, Ph.D. or Ed.D. in mathematics education, or Ph.D. in mathematics. For mathematics instructors at two-year technical colleges, taking courses in technologies served by the two-year college mathematics curriculum is also appropriate. Advanced studies may result in a second master's degree.

Evaluating Credentials

A great deal of specialized knowledge and judgment is required to evaluate a candidate's credentials. For this reason, hiring committees for mathematics

positions at two-year colleges should consist primarily of full-time two-year college mathematics faculty. All staffing decisions related to mathematics instruction, whether full- or part-time, should be made by content specialists.

The Course Content of a Preparatory Program

Mathematics Content

The core of the academic preparation of two-year college mathematics instructors is course work in the mathematical sciences. The mathematics course work for individuals preparing to be two-year college mathematics instructors should include courses chosen from several of the following areas.

Graduate course work should fill gaps, broaden, and extend the undergraduate mathematics background of such individuals.

- Discrete Mathematics
- Computer Science
- Mathematical Modeling and Applications
- Calculus through Vector Calculus
- Differential Equations
- Real Analysis
- Numerical Analysis
- Complex Variables
- Linear Algebra
- Abstract Algebra
- Probability
- Statistics
- History of Mathematics
- Number Theory
- Geometry
- Topology
- Combinatorics

Pedagogical Content

Course work in pedagogy is an important component in the academic preparation of two-year college mathematics instructors. Such course work should be chosen from the areas listed below. Courses in these areas should be offered by universities that prepare two-year college mathematics instructors.

- Psychology of Learning Mathematics
- Methods of Teaching Mathematics
- Organizing and Developing Mathematics Curricula and Programs
- Instructional Technology
- Teaching Developmental Mathematics
- Using Calculators and Computers to Enhance Mathematics Instruction
- Measurement, Evaluation, and Testing
- Teaching Mathematics to Adult Learners
- Teaching Mathematics to Special-Needs Students
- College Mathematics Teaching Seminar (see the Appendix)

Continuing Education

As noted earlier, effective mathematics instructors are active professionals. They read journals, attend professional meetings, and engage in other activities to continue their education. The American Mathematical Association of Two-year Colleges (AMATYC), the Mathematical Association of America (MAA), the National Council of Teachers of Mathematics (NCTM), and other organizations sponsor conferences, offer minicourses and summer institutes, publish books and journals, and advertise other opportunities for continued professional growth. AMATYC, MAA, and NCTM workshops, minicourses, and institutes address many of the mathematical and pedagogical topics listed in the previous section. Participation in these activities is critically important in order for two-year college mathematics faculty to keep up-to-date in their field.

Closing Comments

Part-time Faculty

Ideally, part-time instructors should possesses the same level of preparation and commitment to quality teaching as full-time instructors. An MAA committee report entitled *Responses to the Challenge: Keys to Improving Instruction by Teaching Assistants and Part-Time Instructors* (Case, 1988) addresses this issue at length. We support the views of this report as they pertain to two-year college part-time mathematics faculty.

Variety of Expertise

A mathematics department should be composed of individuals who possess complementary strengths and areas of expertise. This is especially true within a comprehensive community college with a wide variety of degree programs. A mathematics department with experts or specialists in pedagogy, statistics, computing, applied mathematics, analysis, and history of mathematics is generally much stronger than one in which all members have similar academic backgrounds. This together with programmatic needs and candidate qualifications should be taken into account when seeking and hiring full- and part-time faculty.

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Appendix

Outline for a Course in College Mathematics Teaching

Nature of the Course

The course should be a seminar focusing on timely and timeless issues faced by teachers of collegiate mathematics.

Participants

Enrollment should be open to all graduate students in mathematics and mathematics education.

Topics

Topics should be chosen chiefly from among those listed below:

1. Teaching Issues: Motivating ideas, motivating students, conveying the nature of mathematics, effective use of calculators and computers to convey mathematical ideas, learning theory, teaching for understanding, teaching problem solving, characteristics of effective mathematics teachers, individualized instruction, the use and grading of written assignments, teaching adult learners, testing and grading.
2. Program Issues: Curricular trends, textbook selection, course and program development, course and program evaluation, student advising, placement of students.
3. Other Issues: Writing for publication, committee work, professional meetings, service. This discussion should include (a) organizations and publications, (b) types of institutions, and (c) finding and retaining jobs.

Activities

Practice presentations and lessons, discussions of issues, outside readings, sharing of obtained information, writing, computer demonstrations, hands-on computer and calculator activities, guest speakers, videotapes, and films.

Suggested Requirements

1. Attendance at all meetings, participation in all activities including discussions of assigned readings (a bound collection of readings can be made available for purchase at a local outlet.)
2. Term paper, within the area of the impact of new technology on undergraduate mathematics education, or other appropriate topic: one draft plus a final manuscript.
3. A 10-15 minute conference-style presentation with handouts and prepared transparencies.

4. Presentation of a classroom-style lesson with a computer-demonstration, workshop, or other innovative format.
5. Preparation of the following documents: (a) a biographical sketch; (b) a chronological list of graduate courses with date, instructor, and institution; and (c) a full curriculum vitae.

Textbooks could be chosen from:

Albers, D. J., Rodi, S. B., & Watkins, A. E. (Eds). (1985). *New directions in two-year college mathematics: Proceedings of the Sloan Foundation conference on two-year college mathematics.* New York: Springer-Verlag.

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Appendix D

Leading the Way to Systemic Change — The Roles of Mathematics Teacher Educators

University of Nebraska-Lincoln, June 2-4, 1994
Nebraska Union

Workshop Schedule

Thursday, June 2:

3:00 - 6:00 PM	Registration and Check-in [Smith Hall]
6:30 - 7:00 PM	Reception - [Heritage Room]
7:00 - 9:30 PM	Opening Session and Banquet - [Regency Suite]
	Systemic Change: What are the Variables and How Do I Fit In? Glenda Lappan, Michigan State University

Friday, June 3:

	Breakfast in dorms
8:15 - 8:30 AM	Overview and Introductions [Regency Suite]
8:30 - 9:15 AM	*Teacher Preparation: Reforms Based on Standards and Frameworks* Monty Fickel, Chadron State College
9:25 - 10:35 AM	Discussion Session I
	Group A — Regency Suite
	Group B — Heritage Room
	Group C — Room 216
	Group D — Georgian Suite A
	Group E — Georgian Suite B
	Group F — Room 334
10:35 - 10:55 AM	BREAK [Second floor lobby area]
11:00 - 11:45 AM	Reporting and discussion session [Regency Suite]
12:00 - 1:15 PM	Lunch [Selleck Dining Hall]
1:30 - 2:30 PM	Panel Presentation: Pre-service and in-service work with teachers—the role of disciplinary and education faculty [Regency Suite]

Lyle Andersen, Montana
"Systemic Teacher Excellence Preparation Project (STEP)"

Richard Anderson, Louisiana
"Louisiana Collaborative for Excellence in Teacher Preparation (LaCETP)".

Genevieve Knight, Maryland
"Maryland Collaborative for Teacher Preparation (MCTP)"

2:45 - 3:30 pm	Discussion Session II [Rooms as assigned for Session I]
3:30 - 3:45 pm	BREAK [Second floor lobby area]
4:00 - 5:00 pm	Reporting and discussion session [Regency Suite]
5:15 - 7:00 pm	Dinner [Selleck Dining Hall]
7:30 - 9:00 pm	"Birds of a Feather" Sessions, Mabel Lee Hall [Informal discussion sessions, see attached sheet]

Saturday, June 4: Breakfast in dorms

8:30 - 9:15 am	*Building a Mathematics Department — Content courses, teacher preparation programs, and linkages* [Regency Suite] Carolyn Mahoney, University of California, San Marcos
9:30 - 10:30 am	Discussion Session III [Rooms as assigned for Session I]
10:30 - 10:45 am	BREAK [Second floor lobby area]
10:45 - 11:45 am	Reporting and discussion session [Regency Suite]
12:00 - 1:15 pm	Lunch [Selleck Dining Hall]
1:30 - 3:00 pm	Working Session: Refining the Institutional Plan [Rooms as assigned for Session I]
3:00 - 3:15 pm	BREAK
3:15 - 4:00 pm	Final reporting and discussion session [Regency Suite]

Appendix E

Leading the Way to Systemic Change: The Role of Mathematics Teacher Educators

Workshop Participant List

June 2–4, 1994

Glenn Adamson
Box 82
Ottawa University
Ottawa, KS 66067
913-242-5200 x 5466
adamson@isu.ott.edu

Lyle Anderson
8 Gardner Park Drive
Bozeman, MT 59715
406-994-5331
andersen@math.montana.edu

R. D. Anderson
1885 Wooddale Blvd, 11th Floor
Baton Rouge, LA 70806
504-922-0690

Jim Babb
Mathematics Department
Minot State University
Minot, ND 58707
701-857-3075
babb@warp6.cs.misu.nodak.edu

Helen Banzhaf
RFD #1
Seward, NE 68434
402-643-2988
[Seward High School]

Jane Barnard
Armstrong State College
1105 Brittlewood Drive
Savannah, GA 31410
912-921-2057
jane_barnard@mailgate.armstrong.edu

Katherine Becker
Education Department
Creighton University
Omaha, NE
402-556-0082
kbecke@bluejay.creighton.edu

John Beem
Mathematics Department
University of Missouri-Columbia
Columbia, MO 65211
314-882-7877
mathjkb@missou1.missouri.edu

Elizabeth D. Behrens
Mathematics Department
Hastings College
Hastings, NE 68901
401-461-7308
ebehrens@ns.ccsn.edu

Carol T. Benson
Illinois State University
1708 Braden Drive
Normal, IL 61761
309-438-3556
benson@math.ilstu.edu

David Boliver
Department of Math and Stat
University of Central Oklahoma
Edmond, OK 73034
405-341-2980 x 5258
dboliver@aix1.ucok.edu

Daniel Brahier
EDCI - 529 Education Building
Bowling Green State University
Bowling Green, OH 43402
brahier@bgnet.bgsu.edu

Patricia A. Brosnan
Dept. of Theory and Practice
College of Education
The Ohio State University
Columbus, OH 43210
614-292-1257
pbrosnan@magnus.acs.ohio-state.edu

Robert B. Brown
Department of Mathematics
The Ohio State University
231 W. 18th Ave.
Columbus, OH 43210
rbbrown@math.ohio-state.edu

Enid Burrows
Mathematics Department
Plymouth State College
Plymouth, NH 03264
603-535-2307
enidb@psc.plymouth.edu

Don Cannon
Mayville State University
327 East Main
Mayfield, ND
701-786-4895
cannon@ndsuvm1.edu

Joanne R. Carlson
College of Saint Mary
1901 S. 72nd St.
Omaha, NE 68144
402-399-2424

Rao Chivukula
Dept. of Math and Stat
University of Nebraska-Lincoln
P.O. Box 880323
Lincoln, NE 68588-0323
402-472-7222

Margaret Coleman
Rt.1, Box 805
Ruston, LA 71270
318-257-3888
(Louisiana Tech University)

David Cooke
Department of Mathematics
Hastings College
Hastings, NE 68901
402-461-7418
dcooke@ns.ccsn.edu

Gil Daenzer
Concordia College
800 N. Columbia
Seward, NE 68434
402-643-7313

John Dalida
Kansas State University
1737 Plymouth Road
Manhattan, KS 66502
913-776-6481
dalida@ksuvm.ksu.edu

Roger Day
Dept of Mathematics
Campus Box 4520
Illinois State University
Normal, IL 61790-4520
309-438-7096
day@math.ilstu.edu

Ceri B. Dean
High Plains Consortium
2550 S. Parker Rd, Suite 500
Aurora, CO 80014
1-800-949-6387
cdean@mcrel.org

Bill Emerson
Metro State College of Denver
6689 Van Gordon Court
Arvada, CO 80004
303-556-3930
emerson@zeno.mscd.edu

Richard Evans
Plymouth State College
Plymouth, NH 03264
603-535-2487
evans@psc.plymouth.edu

Jim Fejfar
Curriculum & Instruction
214A Henzlik Hall
University of Nebraska-Lincoln
Lincoln, NE 68588
402-472-3389
jfejfar@unlinfo.unl.edu

Monty Fickel
Math Sciences Dept
Chadron State College
Chadron, NE 69337
308-432-6389
mfickel@csc1.csc.edu

Patience O. Fisher
Curriculum & Instruction
29 Henzlik Hall
University of Nebraska-Lincoln
Lincoln, NE 68588
402-472-2389
pfisher@unlnfo.unl.edu

David Fowler
Curriculum & Instruction
30 Henzlik Hall
University of Nebraska-Lincoln
Lincoln, NE 68588
402-472-3347
dfowler@unlinfo.unl.edu

Cathy Franklin
Dept of Secondary Education
Valdosta State University
Valdosta, GA 31698
912-333-5927
franklin@grits.valdosta.peachnet.edu

Heather Fredin
Texas Instruments
515 W. Algonquin Road
Arlington Heights, IL 60005
708-640-2956
hfredin@lobby.ti.com

Alana Gerszewski
Mayville State University
519 3rd St., SE
Mayville, ND 58257
701-786-4744

Neal Grandgenett
107 Kayser Hall
University of Nebraska-Omaha
Omaha, NE 68182
402-554-2690
grandgen@unomaha.edu

Lowell Hagele
Dept. of Mathematics
Union College
3800 S. 48th St
Lincoln, NE 68506
402-486-2548

Marjorie Hartnett
Creighton University
407 Greenbriar Court
Bellevue, NE 68005
402-291-2592

D. Tom Hayes
University of Rio Grande
Rio Grande, OH 45674
614-245-7450
thayes@discovery.oar.net

Lotus Hershberger
Dept. of Math
Campus Box 4520
Illinois State University
Normal, IL 61790-4520
309-438-7089
ldhershb@spider.ilstu.edu

Ted Hodgson
Dept. of Mathematical Sciences
Montana State University
Bozeman, MT 59717
406-994-5350
hodgson@math.montana.edu

Richard G. Holman
Mayville State University
330 3rd St., NE
Mayville, ND 58257
701-786-4730
rholman@plains.nodak.edu

Lynne Ipina
Dept. of Mathematics
University of Wyoming
Laramie, WY 82701
307-766-2318
ipina@plains.uwyo.edu

Terry Jenkins
Dept. of Mathematics
University of Wyoming
Laramie, WY 82701
307-766-3353
tjenkins@uwyo.edu

Jim Johnson
Dept. of Mathematics
Doane College
1860 Fairchild Drive
Crete, NE 68333
402-826-8223
jjohnson@doane.edu

Larry S. Johnson
Metropolitan State College of Denver
5051 West 102nd Ave.
Westminster, CO 80030
303-556-5106
johnson1@mscd.edu

James A. Kaus
Math Sciences Dept
Chadron State College
Chadron, NE 69337
308-432-6407
jkaus@csc1.csc.edu

Beth Kilday
Montana State University
401 Linfield - STEP Project
Bozeman, MT 59717-0281
406-994-6768
kilday@math.montana.edu

Kurt Killion
Dept. of Mathematics
Southwest Missouri State University
Springfield, MO 65804
417-836-6385

Genevieve M. Knight
Coppin State College
2500 West North Ave.
Baltimore, MD 21216-3698
410-383-5422
gknight@coppin.umd.edu

John Koker
Mathematics Department
University of Wisconsin-Oshkosh
Oshkosh, WI 54901-8631
414-424-1333
koker@vaxa.cis.uwosh.edu

N.J. Kuenzi
Mathematics Department
University of Wisconsin-Oshkosh
Oshkosh, WI 54901-8631
414-424-1059
kuenzi@vaxa.cis.uwosh.edu

Cynthia W. Langrail
Illinois State University
1611 Bensington Court
Normal, IL 61761
309-438-2225
langrail@math.ilstu.edu

Glenda Lappan
Department of Mathematics
Michigan State University
East Lansing, MI 48824-0001
21144gtl@msu.bitnet

Jim Leitzel
Department of Mathematics
University of New Hampshire
Kingsbury Hall
Durham, NH 03824
jrcl@christa.unh.edu

Jim Lewis
808 Oldfather Hall
University of Nebraska-Lincoln
Lincoln, NE 68588-0323
402-472-7243
jlewis@unlinfo.unl.edu

Jim Loats
Metropolitan State College of Denver
3505 Endicott Drive
Boulder, CO 80303
303-556-3109
loats@zeno.mscd.edu

Gary Loontjer
Concordia College
131 E. Moffitt
Seward, NE 68434
402-643-4535

Jennifer Luebeck
Montana State University
205 Nelson Story Tower
Bozeman, MT 59715
406-994-6768
luebeck@mathfs.math.montana.edu

Merwin J. Lyng
Mayville State University
420 2nd St. NW
Mayville, ND 58257
701-786-4812

Robert Magelky
Curriculum Consultant, SD SSI
2510 E. Franklin
Pierre, SD 57501
605-773-6400

Carolyn Mahoney
Dept. of Mathematics
CSU - San Marcos
San Marcos, CA 92096-0001
619-752-4090
c_mahoney@csusm.edu

Cheryl Gregerson Malm
Dept. of Math and Stat
235 Garrett-Strong
Northwest Missouri State University
Maryville, MO 64468
816-562-1230
0100211@northwest.missouri.edu

Dennis Malm
Dept. of Math and Stat
235 Garrett-Strong
Northwest Missouri State University
Maryville, MO 64468
816-562-1807
0100114@northwest.missouri.edu

Vicky Mayfield
University of Colorado-Boulder
2346 9th St.
Boulder, CO 80304
303-492-1230
mayfield@ucsu.colorado.edu

Mercedes McGowen
Wm Rainey Harper College
601 Pleasant Place
Streamwood, IL 60107
708-925-6526
mmcgowen@harper.cc.il.us

Lynda S. Morton
Dept. of Mathematics
Southwest Missouri State University
Springfield, MO 65804
417-836-4152
lsm953f@vma.smsu.edu

Barbara Moses
Math Department
Bowling Green State University
Bowling Green, OH 43403
419-372-7464

Don Niemann
Mathematics Department
University of Nebraska-Kearney
Kearney, NE 68849
308-234-8531

Elliott Ostler
Dept. of Teacher Ed, KH 314
University of Nebraska-Omaha
Omaha, NE 68182-0163
ostler@unomaha.edu

Al Otto
Mathematics Department, Box 4520
Illinois State University
Normal, IL 61790-4520
309-438-5767
otto@math.ilstu.edu

Douglas T. Owens
Theory and Practice
The Ohio State University
Arps Hall
1945 N. High St.
Columbus, OH 43210
614-292-8021
owens.93@osu.edu

Jim Paige
Wayne State College
Wayne, NE 68787
402-375-7340

Bill Parker
Department of Mathematics
Kansas State University
825 Harris Ave
Manhattan, KS 66502
913-532-6750
parker@math.ksu.edu

Clyde Paul
Curriculum and Instruction
Southwest Missouri State University
901 S. National
Springfield, MO 65804
417-836-5070
cap821f@smsvma.edu

Charles Pickens
Mathematics Department
University of Nebraska-Kearney
Kearney, NE 68849
308-234-8531

Bob Prielipp
Math Department
University of Wisconsin-Oshkosh
Oshkosh, WI 54901-8631
414-424-1057

Joyce Quella
Dept. of Math and Stat
Winona State University
Winona, MN 55987
507-457-5566
wnquella@vax2.winona.msus.edu

Joe Rabb
Metropolitan State College of
Denver
P.O. Box 323
Pine Junction, CO 80470
303-556-4242
raab@zeno.mscd.edu

Ed Reinke
Concordia College
800 N. Columbia
Seward, NE 68434
402-643-7322

Barbara J. Reys
212 Townsend Hall
University of Missouri-Columbia
Columbia, MO 65211
314-882-8744
cibr@missou1.missouri.edu

Robert E. Reys
212 Townsend Hall
University of Missouri-Columbia
Columbia, MO 65211
314-882-3740
cirreys@missou1.missouri.edu

Bill Roberts
Plymouth State College
Plymouth, NH 03264
603-535-2433
wjr@oz.plymouth.edu

Bernadette Russek
Plymouth State College
Plymouth, NH 03264
603-535-2857
brussek@oz.plymouth.edu

Hassan Saffari
UK - Prestonburg Community College
One Bert T. Combs Drive
Pretonburg, KY 41653
606-886-3863

Connie Schrock
Emporia State University
2545 Willow Lane
Emporia, KS 66801
316-341-5631

Larry Scott
Division Chair
Mathematics Department
Emporia State University
1200 Commercial
Emporia, KS 66801
316-341-5633

Dolores Simoneaux
SLU -749
Southeastern Louisiana University
Hammond, LA 70402
504-549-3459
dsimonezux@selu.edu

Sally Sloan
Dept. Math and Stat
Winona State University
Winona, MN 55987
307-457-5877
ssloan@vax2.winona.msus.edu

Judy Smith
Southwestern College
415 E. 11th
Winfield, KS 67156
316-221-8367

William Speer
Bowling Green State University
1502 Cobblestone
Bowling Green, OH 43402
419-372-7363
wspeer@andy.bgsu.edu

Richard Stratton
Horace Mann Junior High
1212 N. Corona
Colorado Springs, CO 80903-2506
719-471-9573
r.stratton2@genie.geis.com

Kenneth A. Suman
Dept. Math and Stat
Winona State University
Winona, MN 55987
307-457-5371
wnsuman@vax2.winona.msus.edu

Bill Sutherlin
Dept of Mathematics
Southwest Missouri State University
901 S. National
Springfield, MO 65804
417-836-5942

Jane Swafford
Department of Mathematics
Mail Code 4520
Illinois State University
Normal, IL 61790-4520
309-438-7797
swafford@math.ilstu.edu

Earl Swank, Ass't Dean
School of Education
Valdosta State University
Valdosta, GA 31698
912-333-5927
eswank@grits.valdosta.peachnet.edu

Sue Sylvester
Concordia College
St. John Lutheran School
1060 Fairlane
Seward, NE 68434
402-643-4535

Carolyn Talton
Louisiana Tech University
Rt. 3, Box 59-2A
Dubach, LA 71235
318-257-2794

Carol Thornton
Department of Mathematics
Mail Code 4520
Illinois State University
Normal, IL 61790-4520
309-438-7503
thornton@math.ilstu.edu

Mel Thornton
835 Oldfather Hall
University of Nebraska-Lincoln
Lincoln, NE 68588-0323
402-472-7243
mthornto@unlinfo.unl.edu

David Thronson
Westside High School
3017 Pedersen Drive
Omaha, NE 68144
402-390-2187

Martha Tietze
Shawnee Mission School District
#512
7807 Acuff Lane
Lenexa, KS 66216
913-962-3100
kssmnw@delphi.com

Joann Utter
Kansas State University
15400 W. 80th Place
Lenexa, KS 66219
816-353-1009

Sigrid Wagner
257 Arps Hall
The Ohio State University
1945 N. High St.
Columbus, OH 43210
614-292-8058
swagner+@osu.edu

Darlene Whitkanack
Northern Illinois University
2308 Fairland Drive
Sycamore, IL 60178
815-753-6748
darlene@math.nui.edu

Stephanie Williamson
Louisiana Systemic Initiatives Program
1885 Wooddale Blvd., 11th Floor
Baton Rouge, LA 70806
swilliam@ssi.edc.org

Mary Jane Wolfe
University of Rio Grande
P.O. Box 131
Rio Grande, OH 45674
614-245-7243
mwolfe@discovery.oar.net

Robert W. Wolfe
University of Rio Grande
P.O. Box 131
Rio Grande, OH 45674
614-245-7247
rwwolfe@discovery.oar.net

Gordon Woodward
Dept. of Math and Stat
University of Nebraska-Lincoln
Lincoln, NE 68588-0323
402-472-7239
gwoodward@unlinfo.unl.edu

Betsy Yanik
Division of Math & Comp Sci
Emporia State University
Emporia, KS 66801
316-341-5630
ynaikeli@esumail.emporia.edu

NOTES

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Signature: Patience O. Fisher

Printed Name/Position/Title: Patience O. Fisher, Assistant Prof. Math Education

Organization/Address: University of Nebraska-Lincoln
Pfisher@unlinfo.unl.edu

Telephone: (402) 472-2389

FAX: (402) 472-8317

E-Mail Address:

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